GENERAL SYSTEM ANALYSIS AND SIMULATION APPROACH: A PRELIMINARY APPLICATION TO NIGERIAN FISHERIES

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ABSTRACT

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The development of Nigeria's fisheries organization with respect to policy formulation, research and development efforts, and resource allocations was

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The development of Nigeria's fisheries organization with respect to policy formulation, research and development efforts, and resource allocations was

described. The description covered the period between 1942 and 1972, and the six components of the fisheries which include canoe, trawl (inshore and distant-water), pond, riverine, and lakes fisheries. The need for research and development coordination at the national level including a data bank and collection of basic data on regular basis was established.

In developing the research approach, GSASA, presented in the thesis, it was noted that neoclassical assumption of perfect knowledge is unrealistic for investigations of developmental problems. It was argued, apriori, that there is neither perfect knowledge nor perfect ignorance in the real world; that what we have are degrees of knowledge which can be improved through learning. Development planning was described as activities designed to achieve a future situation from an inferred present one, and inferences as subjective interpretations of our sense perceptions thus establishing the need for interaction which is the focal point of the general system analysis and simulation approach, GSASA.

GSASA, it was argued, follows the principles of traditional scientific research method and is particularly flexible. Using diagrams, the iterative process of GSASA for solving developmental problems was described, parallels and distinctions were shown between

GSASA and the Bayesian approach, and how specialized techniques such as LP, NLP, cost-benefit analysis, etc., can be appropriately used within GSASA framework.

The main problem of fisheries development was identified as the allocation of scarce resources in an environment of complex interactions among physical, social, economic, and political components, the interactions involving multiple and often conflicting values. Several needs were identified including the need to eliminate or reduce malnutrition. It was argued that acquisition of information was a necessary step to solving developmental problems and that planning is an intersectoral activity. It was argued apriori that there were legal, administrative, and political bases for implementing policy alternatives that might be found admissible for seeking solutions to developmental problems.

It was shown that GSASA can be used to study development policies in fisheries by showing conceptually how Nigeria's fisheries can be studied using GSASA and a case was made for the use of nonstochastic equations in analysis of data. The practicality of the approach (GSASA) was then demonstrated by constructing a preliminary operational model of a component of Nigeria's fisheries subsector.

The need for data in policy analysis and the data requirements of the fisheries subsector were discussed. A preliminary list of data that need to be collected was given for nine data categories; this was followed by a discussion of the procedures for collecting the data and an outline of a six-stage research plan.

Costs and benefits were discussed first from a general perspective and then with specific reference to our proposed research project. In discussing specific costs and benefits of the project, we considered costs and benefits to the ordinary Nigerian, the fisherman, the investigator, and the government.

Despite its preliminary nature the thesis contributed, among other things, a comprehensive overview of Nigerian fisheries with respect to research activities, production process, resources, processing, and marketing; a comprehensive identification of fisheries development needs and problems; a preliminary model for studying fisheries policy problems; a research plan to study fisheries policies at both the state and national levels; a basis for establishing data bank for Nigerian fisheries; and showing that it is possible to use GSASA for fisheries policy and program analysis.

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A THESIS

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DEDICATED TO

Mohammed-Alidu Adigun

Patricia Alexa

Dauda Oyesegun

and

Adebanji Adedeji

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CHAPTER I

A DESCRIPTION OF NIGERIAN FISHERIES AND NIGERIAN FISHERIES RESEARCH

Introduction

The Role of Fisheries in Nigerian Economic Development

The contribution that fisheries development can make to Nigerian economic development is, perhaps, small compared to the contribution expected from agriculture and petroleum. However, the development of agriculture and petroleum is dependent on the availability of many types of labor services, both in quantity and in quality. It cannot be denied that these labor services are products of investment in human capital, the most important of which is investment in the health of the people, and food is an important input in maintaining good health while a balanced diet is a prerequisite to economic development.

The success of a nation's development program is dependent, in part, on its human resources which, to function efficiently, must be provided with a balanced diet. Agriculture provides many foods containing most of the nutrients necessary for healthy functioning of the human body, but only a few of them contain large quantities of these nutrients, particularly protein and fats; fish (and livestock, of course) does contain these essential nutrients. Consequently, the development of the fisheries industry can supplement that of agriculture in providing a balanced diet.

General Background of Nigerian Fisheries Development

Nigeria, with a population of over 55 million, is the largest single consumer of fish and fish products (in terms of total value of fish consumed by the nation) in West Africa. Located on the southern coast of West Africa, Nigeria has about 500 miles of coastline and her waters are known to be rich in fishery resources, but Nigeria has not paid much attention to fishery development.

The first steps Nigeria took towards the development of her fishing industry were in 1942 when the experiences of World War II and the discontinuity of imports from Europe accentuated the need for developing local resources in all fields, including fisheries. At this time a survey of the fisheries industry was undertaken (25). This study, organized by the colonial government, was limited to a study of canoe fishery and to some preliminary experiments in fish culture in

brackish waters. At the end of the war a permanent fisheries organization was established as a division of the Department of Commerce and Industry.

The activities of the division were limited to trawling surveys around Lagos and off the Camerouns. Consequently, little is known about the fisheries resources of Nigeria. In 1953, when Nigeria had a new constitution under which the three regions--Western, Eastern, and Northern--became autonomous, fisheries became a regional responsibility. The federal government was given a minor role in regional fisheries. At the federal level fisheries became a service of the Federal Ministry of Economic Development, but in the regions it was a division of the Ministry of Agriculture and Natural Resources (MANR).

According to the constitution, fisheries research was a subject in which both regional and federal governments were equally competent to engage, while fisheries development was solely the responsibility of the regions. Thus, in the regions, the Federal Fisheries Service (FFS) had no development "initiative" in fisheries. Research and development within the federal territory of Lagos and in the international waters off the coast were made the responsibility of FFS. In addition, the FFS could participate on any research question for which a regional government invited its participation. FFS could not initiate research in any region unless invited to do so.

Following the reorganization of the country into twelve states in 1967, regional powers and responsibilities passed on to the states by decree. Each state became responsible for fisheries research and development within its own territory. A state could either engage in research itself or it could call on the FFS (now Federal Department of Fisheries, FDF) for assistance. With the creation of states, the Federal Territory of Lagos became part of the Lagos State, thus reducing FDF's primary responsibility to research in international waters off Nigeria's coast. In addition, the FDF was responsible for fisheries education and training for the federation. However, initiative for research and development remained with the states and consequently there was no national coordination in fisheries research and development.

By 1968 the acute need for central coordination to avoid duplication of research and development efforts was recognized. The FDF was assigned the role of over-all coordinator. In order to effectuate this, a division of planning was created in 1969 within the department.

This new division is responsible for:

A. The development of a national fisheries plan which will take the various needs and aspirations of the twelve states into account. It is also supposed to insure harmonious progress and coordinated effort towards achieving planned national objectives. This function involves:

1. Collection of information on state plans, projects, needs, and problems;
2. Collection of fishery statistics from all the states on production, sales, prices, etc.;
3. Analysis of data from 2 in the light of information in 1; and
4. Formulation of policies and drawing up action programs for consideration by both state and federal governments.

B. The establishment of a data bank to provide information for established and new investors in the fisheries industry.

C. The training of the manpower required for development in the public and private sectors of the industry.

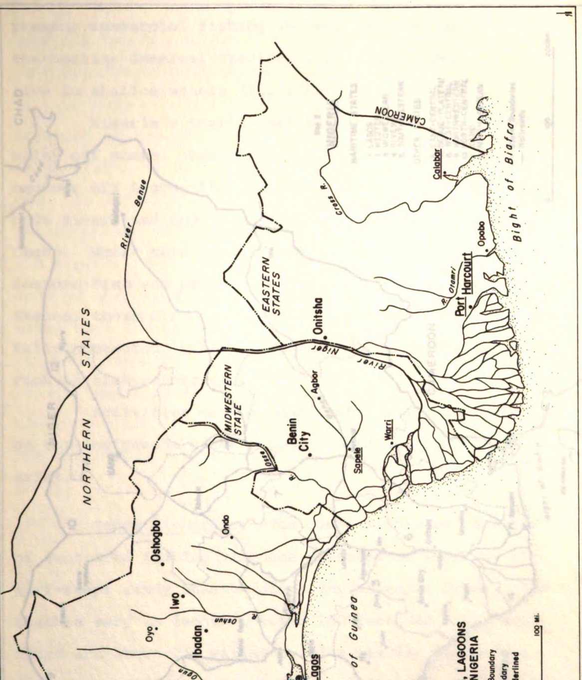
By 1971, when the report for the National Seminar (32) was being prepared, there were two senior members in this division. Both were biologists. It was planned for them to receive further training, especially in economics, in order to enhance their effectiveness in guiding the division. By the beginning of 1972, the more senior of the two, like some members from the research division, left the department to join the National Research Council as a fisheries biologist. The Federal Department of Fisheries thus remains understaffed, especially its planning division which is the most important division in fisheries development.

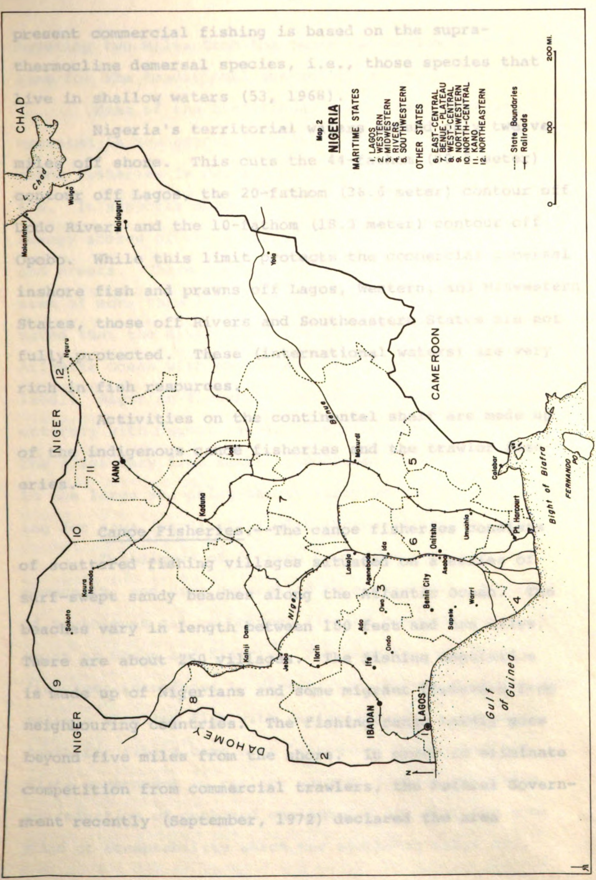
Nigerian Fisheries Subsectors and Components

Marine Fisheries (Coastal and Ocean Fisheries)

The Nigerian 500-mile shoreline (see Map 1) forms the southern boundary of five of the twelve states of Nigeria (see Map 2). These maritime states are Lagos, Midwestern, Rivers, Southeastern, and Western states with shoreline mileage of approximately 112, 88, 142, 80, and 58, respectively.

The continental shelf is narrow compared with that off Dakar, Senegal, for example. It is widest on the eastern part where it is about 50 miles off the Opobo River and narrowest in the Western part, being 18 miles off Lagos and only 8 miles off Lekki in the Western State (Map 1). The Avon's Deep is quite close to land here. Although the maximum depth of the shelf is 200 meters, the present commercial fishing hardly extends beyond the 30-meter contour which, on the average, is less than fifteen miles from the coast. The reason is that the


Map 1
COASTLINE, CREEKS, LAGOONS AND RIVERS in NIGERIA
International Boundary
Regional Boundary
Port Cities are Underlined
0
50
100 MI.
N
DAHOMEY
WESTERN STATE
NORTHERN STATES
MIDWESTERN STATE
EASTERN STATES
CAMEROON
Badagry
Lagos
Ibadan
Oyo
Iwo
Oshogbo
Ondo
Benin City
Sapele
Warri
Agbor
Onitsha
Port Harcourt
Opobo
Calabar
R. Ogun
R. Oshun
R. Osse
River Niger
River Benue
Cross R.
Gulf of Guinea
Bight of Biafra


Map 2
NIGERIA
MARITIME STATES
1. LAGOS
2. WESTERN
3. MIDWESTERN
4. RIVERS
5. SOUTHWESTERN
OTHER STATES
6. EAST-CENTRAL
7. BENUE-PLATEAU
8. WEST-CENTRAL
9. NORTHWESTERN
10. NORTH-CENTRAL
11. KANO
12. NORTHEASTERN
State Boundaries
Railroads
0
100
200 MI.
CHAD
Chad
NIGER
DAHOMEY
CAMEROON
Gulf of Guinea
Bight of Biafra
FERNANDO PO
Malamfatori
Wulgo
Maiduguri
Yola
Nguru
KANO
Kaduna
Sokoto
Kaura Namoda
Kainji Dam
Jebba
Ilorin
Niger
Benue
Makurdi
Lokoja
Ida
Agenebode
Onitsha
Asaba
Umuahia
Calabar
Pt. Harcourt
Warri
Sapele
Benin City
Owo
Ado
Ondo
Ife
IBADAN
LAGOS

present commercial fishing is based on the supra-thermocline demersal species, i.e., those species that live in shallow waters (53, 1968).

Nigeria's territorial waters extend only twelve miles off shore. This cuts the 44-fathom (80.5 meter) contour off Lagos, the 20-fathom (36.6 meter) contour off Dodo River, and the 10-fathom (18.3 meter) contour off Opobo. While this limit protects the commercial demersal inshore fish and prawns off Lagos, Western, and Miswestern States, those off Rivers and Southeastern States are not fully protected. These (international waters) are very rich in fish resources.

Activities on the continental shelf are made up of the indigenous canoe fisheries and the trawler fisheries.

Canoe Fisheries.--The canoe fisheries consists of scattered fishing villages situated on a series of surf-swept sandy beaches along the Atlantic Ocean. The beaches vary in length between 100 feet and ten miles. There are about 250 villages. The fishing population is made up of Nigerians and some migrant fishermen from neighbouring countries. The fishing range hardly goes beyond five miles from the shore. In order to eliminate competition from commercial trawlers, the Federal Government recently (September, 1972) declared the area covering two miles from the shore the exclusive fishing zone for the traditional sea-going canoes.

Most of the traditional canoes are, however, operated in the brackish waters. This section of the canoe fisheries is restricted to areas south of latitude 6°N. It supports numerous villages scattered among the swampy shores of the vast network of estuaries, lagoons, and creeks. There are more than 5,000 villages in this area of more than 7,500 square miles. It has been estimated that the Niger alone has about 20 entrances to the Atlantic Ocean with an average length of 80 miles (25, 1968). Nigerian fishermen operating in this area work entirely with dugout canoes of varied types and sizes. The sizes vary from small line-canoes worked by one man to the large sea-going canoes carrying ten men and fishing for sawa (sardinella) with large encircling nets.

Techniques of fishing pass from community to community, and from generation to generation. Exchange of techniques can be between fishing communities as far apart as Ghana and Nigeria. For example, the Ghana fishermen introduced to Nigeria the technique of catching pelagic shoaling fish with encircling nets. Recently, synthetic fibers have been introduced by the Western State government to replace natural fibers, but there introduction of outboard engines did not meet the same kind of acceptability which the synthetic fibre had.

Study of the selective adoption of technological change may help to identify successful means of introducing change to the traditional canoe fisheries on which about two million Nigerians are dependent.

Trawling.--Trawling represents a more advanced technology than canoeing on the scale of fishing technology. The trawler fleet consists of inshore and distant water trawlers based mainly in Lagos with a few in Port Harcourt. The fleet was established in 1956 with only one registered vessel (25, 1968). By 1967, the fleet had grown to 24 trawlers, ranging in size between 20 and 500 gross tonnage. Prior to 1965 most of these vessels exploited demersal fishes around Lagos, between Lekki and the Dahomey border, in an area of about 500 square miles. The range of fishing was between the 3- and 20-fathom contours until 1972 when they had to move out to about the 5- to 20-fathom range.

Initially, the trawlers caught prawns as by-catches during fishing trips. But, as a result of decreasing fish catches coupled with increasing economic returns to prawns, especially Penaeus duorarum, which are known to be abundant off the Niger delta areas (19, 25, 45, 59), many trawlers changed from fish fishing to prawn fishing. They also extended their fishing area eastwards to the prawn rich grounds off the Niger delta. In 1965 only one vessel was registered for prawn fishing as against fifteen fish vessels, but by 1967 there were fifteen prawn fishing vessels and only eight vessels remained fish fishing trawlers. These trawlers are owned by Nigerians or Nigeria-based fishing companies.

Distant-water Fisheries.--The distant-water, factory-type trawlers represent the most technologically advanced component of the Nigerian fisheries industry. These distant-water trawlers are much bigger than the coastal water trawlers. These land fish which are already deep frozen. The ports of landing are Lagos and Port Harcourt. These vessels operate mostly in international waters, especially in the areas west of Dakar, Senegal, south of Freetown, Sierra Leone, and west of Namibia and Angola. Between 1965 and 1968 there were more than 70 of these trawlers, ranging in size between 1,000 and 3,000 gross tonnage, registered in Nigeria. In 1967, 37 of them landed fish in Lagos. Of these, five were owned by a Nigerian company, while the rest of them were on charter to Nigeria-based companies. The fish landed by chartered vessels are regarded as fish exports to Nigeria thus making Nigeria-based fishing companies importing agents, for they do not own the fishing vessels.

Inland Fisheries

Ponds.--Following the regionalization of fisheries, the Western region (now Western State) paid a

considerable amount of attention to the establishment and improvement of homestead fish ponds. By 1961, 132 sites had been investigated and 72 ponds were constructed and in production. The species involved in the stocking was Tilapia. By the end of 1967, Western State had 120 small-scale ponds, stocked with Tilapia or carp, in operation. The state also established a 350-acre fish farm in 1968. In 1971, when the report of the fisheries committee was being compiled (53), it was found that growing tilapia was not as profitable as growing carp.

There was relatively small emphasis put on ponds in the east. Before the civil war there were only 20 ponds and reservoirs in the Eastern region. There is very little known about these ponds now.

In 1951, an industrial fish farm was established at Panyam, Benue-Plateau State. This farm was to be run as a commercial concern designed to serve as a demonstration and to provide information for the establishment of similar farms in other parts of the country. Tilapia and carp were experimentally tested. Carp showed promising results, but Tilapia results were not very encouraging. For example, the rate of growth of Tilapia was 0.6 lbs./acre-day compared with 1.75 lbs./acre-day for carp (25, 1961).

Although it is difficult to speculate what the success of fish-pond farming will be in the future, available information, especially from the Western State, does not justify the priority given to pond farming in the 1970-74 development plan. In this plan 13.6 percent of total planned expenditure for fisheries is allocated to pond farming (53, p. 57).

Rivers.--The riverine fisheries are located in areas north of latitude 5°30'N in the delta and eastern sectors, and above latitude 6°30'N in the western part of Nigeria. The total length of the many rivers is well over 4,000 miles, and there are more than 3,000 villages along the rivers where fishermen engage in fishing on a full-time or part-time basis.

The most important of the river systems is the Niger-Benue system. Apart from settled fishermen along the banks of the Niger and the Benue rivers, there is a considerable number of fishermen who move down the Niger and the Benue as the floods subside, establishing camps and operating nets, hooks, and traps for fishing and using dug-out canoes. These migrant fishermen return to their farms just before the rainy season starts. In the country as a whole, river fishing is a supplementary occupation. We have very little knowledge of the potential production of the riverine fisheries.

Lakes.--There are two lakes in Nigeria, and one of them is shared by Nigeria and other countries. Lake

Chad, a natural lake is shared with the republics of Niger, Chad, and the Cameroons. The artificial Lake Kainji was created by Nigeria's construction of the Kainji Dam, completed in 1968.

Lake Chad supports an extensive indigenous fishery. Its total surface area varies between 5,000 and 10,000 square miles, depending on the season. The Nigerian sector is about 1,000 and 2,000 square miles with a coastline of about 160 miles. There are about 50 important fishing villages along the bank, but there are over 200 villages on islands in the lake.

The then Northern Nigerian government paid a lot of attention to Lake Chad fisheries, the main fisheries of the north. The recent introduction of better fishing crafts (20-feet open fishing craft [23]), gear and nets, and the establishment of credit programs enabled the fishermen to extend their range of fishing to about 20 miles off-shore. In preparing the fisheries report (53), the administration of the credit program, especially the method of repayment of loans, was found to be inefficient and in need of improvement.

Kainji Lake covers an area of about 500 square miles and the biological studies indicate that its fauna can support the species of fish found in the Niger-Benue River system. It is too early to speculate on its potentials.

Fisheries Resources

The areas of the ocean in which biological activity in the surface waters is most intense are those where upwelling of deep water occurs, and it is in such areas that many of the great fisheries of the world occur. On the western seaboard there are two main cold currents in which deep water rises to the surface. These are the Benguela Current flowing northwards along the west coast of Namibia and Angola, and the Canary Current flowing south along the coasts of Morocco, Mauritania, and Senegal. The oceanographic area of equatorial West Africa lies between these two areas of relatively cold and rich water, and it is occupied by the waters of the eastward flowing, warm Guinea Current. Upwelling of deep water occurs in this region only off the Ghana coast and farther out to sea. Except in these upwelling areas, the waters of the Gulf of Guinea are relatively poor in the nutrients which determine fish productivity. However, Nigeria is fortunate for her heavy rainfall along the coast. The rainfall produces very heavy riverine debris which enriches the nutrient content of the sea bottom, especially off river mouths. Much of Nigeria's coastline is deltaic, and thus there is a very considerable volume of organic debris entering the sea and forming deposits of mud off the river mouths, particularly the Niger-Benue system.

Two more factors are important in determining the extent of the fisheries resources. These are the width of the continental shelf, and the existence of a permanent thermocline. Demersal fisheries hardly extend below the continental shelf, which in effect limits the range of demersal fish trawling. The thermocline, where warm surface water meets the cooler deep water, acts as a natural barrier to fish. Off Nigeria's coast the thermocline may be expected to meet the continental shelf ten or twelve miles from the shore along the 50-meter contour. The fisheries resources that are located in these areas can be grouped into four categories. These are (a) pelagic (including tuna), (b) demersal, (c) prawns, and (d) shellfish. The other fisheries resources from inland waters will be treated as freshwater fish.

Probably the greatest saltwater fisheries resources in Nigerian waters are the stocks of tunas and tuna-like fishes--the large pelagic fish which "range the surface waters of the tropical and semitropical seas far from land, often in shoals of very large size" (45). The areas of richest tuna fishing stretch from Sierra Leone northwards to Senegal and eastwards to Fernando Po, off Nigeria, and south to the coast of Angola. The area of tuna concentration coincides with areas of great biological activity (45), which makes Nigeria's offshore a very likely place for tuna existence. It is difficult to describe these resources in terms of figures of potential production because studies which can provide such information are yet to be undertaken. However, Longhurst (45) and Chapman (8) agree that tuna is one of the biggest fisheries resources that Nigeria can exploit profitably.

The other pelagic fisheries in Nigeria are clupeids, the most important of which are bonga or efolo (Ethmalosa fimbriata), sawa (Sardinella eba and Sardinella cameronensis), and afioro (Sardinella aurita). Bonga, sawa, and afioro are shoaling fish which may occur at certain seasons in shoals or schools of very great size. Bonga are usually found in shallow waters in the inshore area, at the estuaries and lagoons during the dry season. Sawa are in the open sea most of the time but enter the estuaries at times because they can tolerate reduced salinity. Sardinella eba are found on the western coast between Lekki and Lagos, while Sardinella cameronensis are found east of Lekki. Afioro (Sardinella aurita), which are intolerant to fresh water, are found only in the open sea. More information is needed in order to understand and estimate the extent of these resources.

The demersal fish resources of Nigeria follow the pattern typical of the Gulf of Guinea. In waters shallower than 100 meters, two assemblages of species can be identified (45). The first assemblage is composed mainly of silver or gray fish such as croakers (Otolithus), grunters (Pomadasys), spadefish (Drepane), and threadfins (Galeoides), to mention a few of the commercial species. The other assemblage consists mainly of red fish such as breams (Pagrus) and snappers (Lutjanus), for example. The two assemblages do not mingle. The gray fish occur above the thermocline in the warm surface water feeding on the benthic invertebrates which occur on mud and muddy sand deposits. On the other hand, the red fish occur above and below the thermocline but on relatively clean sand and, in particular, on sand with shell and coral. Below the thermocline, where there is no competition from the gray or silver fish, the red fish occur on all deposits from coral to mud. Like the pelagic and tuna fisheries, we have very little knowledge on the potential production from the demersal resources.

The experience in the Gulf of Mexico and in the South China Sea has shown that wherever there are extensive areas of soft mud deposits in tropical seas, large prawns are generally abundant. Prawns may form the object of valuable fisheries as they did in the Gulf of Mexico. Nigeria is exceptionally well placed in this respect because of the great mud deposits in the Bight of Biafra. The deposits are not only extensive but they are now known to be rich in prawns. This discovery has already affected the structure of trawl fishing in Nigeria.

There is little information on shellfish resources, except the speculation that the brackish waters are rich in oysters, especially the mangrove oysters. Judging from the amount of empty oyster shells in the fishing villages, it may be worthwhile to investigate the extent of oyster occurrence especially in the deltaic areas.

The freshwater fisheries resources in the rivers and lakes are extensive. The drainage system comprising the rivers Niger and Benue forms the major part of the inland riverine fisheries resources of Nigeria. Biological studies done in connection with the Jebba Dam Project identified 73 species (45). Most abundant of the species are Alestes and Citharinus. Lake Chad is very productive but Kainji Lake's potential is not known in full yet. Tilapia and carp are the most common species that are being stocked in the fish farm operations, while catfish is most common in the rivers and streams that flow all over the country.

Production

It is very difficult to discuss the present production figures of Nigerian fisheries because of a lack of consistent data. For example, the FAO reported production to be 75,000 metric tons per annum in the period 1961-63, while another report gave 1964 production figures as 58,000 metric tons. When the members of the fisheries committee used results of surveys and national data, they estimated production to be 148,000 metric tons in 1970 without any evidence of any breakthrough in production technology, large increase in fishing population, or improved efficiency in the use of current technology to explain the sudden increase in production between 1964 and 1970 (53). Idusogie et al. (35) estimated fish production for 1968-69 as 800,000 metric tons which is more than four times the initial estimate used in (53). In the midst of this confusion there is an urgent need for reconciliation. This point is discussed in more detail in Chapter VI.

Marketing and Distribution

Nigeria's traditional marketing and distribution system is very complex and advanced considering the constraints under which it operates. The movement and trade of fish products follow the general pattern that any product of our cottage industry follows. The system is dominated by women (particularly in the Western State), but some men participate in the system, especially in the transportation section. There are two distinct groups of participants. For lack of a better name, the first group will be referred to as the middlemen and the second as the retailer. The middleman is a trader who buys fish (for that matter, any product) from the fishermen or their representatives (usually their wives), packages them, and transports them to distant markets. The middleman and fisherman bargain vigorously before agreeing on a price which depends on the quality and type (species) of fish offered for sale. The only exception to this price determination is one in which the middleman is a creditor to the fisherman. In this case, there is a contractual arrangement whereby the fisherman is essentially a price-taker. The middleman sells fish to the retailer who then displays it in the market stalls for sale to consumers.

Wholesale transactions for fresh fish are carried out at the landing sites. Fresh fish from canoes are landed unsorted, unpackaged, and are not iced, whereas fresh fish from inshore trawlers are often iced, and landed in 40-lb. wooden boxes after they had been sorted into size and species categories. Sale of fresh fish is usually to middlemen who carry them to local markets for retail sales. The sale of smoked fish takes place at the processing sites which are usually close to shore and to the fishing village, the residence of the supplier. Frozen fish are sold to middlemen or dealers directly from cold stores which are often located on the premises of marketing companies. The fish are sold in 66-lb. (30-kg.) cartons to accredited dealers who, in some cases, undertake the transportation of the fish to retailers in remote towns. Some companies provide small cold storage facilities (10-40-ton capacity) in depots scattered all over the hinterland.

Fish may be sold either wholesale or retail by the producer and/or through a series of middlemen. The participation of middlemen results in a 25 to 50 percent mark-up in prices by the time the fish reaches the consumer. The canoe fishermen have no control over the prices charged by either the middlemen or the retailers, but the big fishing companies exercise control over the mark-up that a dealer and/or retailer can put on the price he paid for the fish. Except in the case of frozen and iced fish, sales of fish are rarely by weight. Prices depend on the bargaining power of the buyer, both at the wholesale and retail levels. Besides the bargaining power, prices also depend on the size, the species, and on the preservation or processing method of the fish. Other factors that affect fish prices include the location of the market town, the distance of the fishing village from the market town, general fish demand, consumer's preference, and the supplier's need for cash and/or certain consumer goods such as clothing, drinks, and food.

In the canoe fisheries, fresh fish is obtained wholesale from the fisherman and retailed to the consumer. The middleman is either a relative, a customer, or a creditor of the fisherman. The fish is not usually sorted into sizes or species by the supplier, except in the case of bonga. The whole content of the boat is emptied into baskets of varying sizes (ranging between 12 lbs. and 40 lbs. in weight) which are then bought by the middleman after a hard bargaining session. In the case of the creditor-middleman, there is no bargaining. The fisherman just hands over the total catch to the middleman who sells it on his behalf. He retains part of the proceeds as installment payment on the fisherman's indebtedness and gives him (the fisherman) whatever excess there is.

The distribution of fish is fairly complex, yet the distribution system has been described as being primitive and inefficient by many researchers (e.g., 19, 35, 53). This charge can be ascribed to a lack of understanding of the system.

Frozen fish landed in Lagos is transported in refrigerated trucks to distant market centers, including Ibadan, Ife, Ado Ekiti, Benin, Sapele, Asaba, and Ilorin (see Map 2). The distance from Lagos ranges between 90 miles and over 300 miles. A small quantity was experimentally delivered by rail to middlemen in Kano (about 700 miles from Lagos) and the fish arrived in good condition. Fish landed in Port Harcourt are trucked to Aba, Umuahia, and Onitsha--an average of 80 miles from port of landing.

Fresh fish from inshore trawlers and from fresh-water fisheries, especially from the maritime states, are located close to densely populated areas where demand for fish usually exceeds its supply. Consequently, the distribution of fresh fish does not extend beyond a 25-mile radius. Besides, only about 25 percent of the fish caught are sold fresh, while the remaining 75 percent are processed and transported to distant markets.

Processed fish--which includes smoked fish and dried shrimp from the rivers Niger and Benue, smoked bonga which is the most important product of the canoe fisheries, and sun-dried fish and banda from Lake Chad--are distributed through a marketing network that covers the entire country. Lokoja, for example, serves as a collecting point for smoked fish from Yola (52 miles from the Cameroon's border) and the neighbouring towns in the Cameroon Republic; from Ibi (252 miles from Lokoja) and from Makurdi (158 miles). Then from Lokoja, the fish are moved to Ida and Agenebode. From Ida the fish go to Onitsha and Asaba by canoe on the river Niger, and from Agenebode the fish are distributed to Benin, Owo, Ibadan, and other towns in the West. Jebba is another collecting point on the Niger-Benue system. Fish move from here to Ilorin (100 miles) and Ibadan (200 miles) for further distribution.

The bonga trade has five collecting centers; namely, Port Harcourt, Warri, Ondo, Epe, and Lagos, from which smoked bonga is distributed to all parts of the country reaching as far north as Kano from Warri.

The processed fish originating from Lake Chad are collected at the three main entrepôts--Malamfatori, Baga, and Wulgo Banda--from which the fish are shipped to Maiduguri, the distribution center. From there, they are trucked to Kano and Jos, and then distributed by rail and road to the southern states, reaching as far south as Lagos and Port Harcourt.

It is evident from the examples given above that the distribution of fish is not an immediate problem and that the marketing system will respond to changes in volume as the need arises. This is not to say that the system should not be studied with a view to making it more efficient, but there is no distribution bottleneck. Packaging, storage, and price margins are a different set of problems which, if solved, may increase the distribution efficiency and this may reduce prices paid by consumers. Another problem that must be investigated is the level of wastage in the distribution system.

Nigerian Fisheries Research

Just before the reorganization of the country into states, the Federal Fisheries Service (now Federal Department of Fisheries) had four research vessels. Only one of these was equipped for trawling and routine oceanographic work. It had room and laboratory for two scientists in addition to the normal complement of a fishing trawler. The remaining three were small crafts one of which was at the end of its economic life by 1961. It was no longer in usable condition by 1970. One of the other two could only go out to sea if the weather was good. The last one was not equipped for any prolonged trip. In essence, the FFS (Federal Fisheries Service) had only one research vessel.

The research staff was made up of four biologists, two engineering officers, two master fishermen, and one administrative assistant.

The Western Region had five small boats none of which was designed as a research vessel despite the fact that research is more a regional responsibility than that of the federal government. There were five biologists of varying ranks in the Western Region, and one master fisherman. The Eastern Region had two fishing vessels none of which was equipped for research. There were four biologists in the research section. The Northern Region had one small boat, one fishing punt, two biologists, one superintendent, and one assistant superintendent. There was no economist in any of the organizations.

It is obvious, from the research facilities and the research staff provided by the Nigerian governments, that there was very little research that could be done on a regular basis, since the means for such endeavor were not provided.

The FFS and the regional fisheries divisions (RFD) were formed with well-defined programs (discussed elsewhere). While FFS assumed responsibility for applied and operation research and general liasion with neighbouring countries such as Chad, Niger, and the Cameroons, the regional divisions were concerned with the development of the sea and the inland fisheries. The marine research programs of FFS consisted mainly of the collection of oceanographic data; of biometric studies of different species, particularly those exploited off Lagos; of bionomic and biometric studies of croakers; and of the collection of fish landing statistics for the trawler fleet. The regional divisions concentrated on socio-economic work among the fishermen. This is particularly true of the Western Region where extension work is well established for agriculture. The effects of the introduction of new technology, in the form of new fishing techniques and new inputs, were investigated between

1965 and 1968 in the Western and Midwestern States (19). This study was about the most comprehensive study ever undertaken in the country.

Because of inadequate staff and research facilities the basic data bank necessary for policy analysis is not available. The practice of the regions was to ask the federal service for experts to help develop and execute research programs whenever there was need for information for policy decisions. Both the FFS and the RFD relied on reports of studies conducted by itinerant researchers whose reports were sometimes supplemented by FFS annual reports. The reports emphasize biological investigations. Often the findings, and hence the recommendations, of these experts conflict.

The major research reports that treated fisheries development in Nigeria or in some parts of Nigeria include FAO reports (15, 17, 18, 19, 20, 21, 22, 23); the report of the National Agricultural Advisory Committee (52); the FFS annual reports (25); and reports by Scott (59), Chapman (8), and Longhurst (45).

As a result of the experts' analysis of the existing information, one of the FAO reports (15) recommended, among other things, that low priority should be given to tuna and sawa fisheries. The reasons given are that Nigeria's waters are not rich in tuna and little is known on the available quantity of sawa.

Nigeria should therefore encourage fish farming and importation of fish. On the other hand, Longhurst (45) observed large stocks of tuna, especially yellowfin and skipjack, off Nigerian shores. Further, Chapman (8) regarded tuna as the largest readily available fishery resource to Nigeria, situated as Nigeria is in the center of tuna occurrence and abundance. He wrote, "If I were the Government of Nigeria and wanted 100,000 tons of high quality animal protein additionally per year with which to feed my people, I would concentrate on building up my tuna fishery, the yellowfin primarily for export and the skipjack primarily for local consumption. . . ." This statement was confirmed by the report of a fisheries development conference held in 1971, in Casablanca, Morocco (16). The same kind of contradiction exists for sawa. When different research reports give contradictory information they fail, as do reports on Nigerian fisheries, to provide the basis for decisions. The policy maker will want to know whose information he should accept as correct. This is a question that requires fundamental research and the collection of basic data in order to reconcile conflicts in the reports. This illustrates the need for basic data discussed later in Chapter VI.

Despite the conflicts and contradictions, almost all the reports agreed on the need for construction of fisheries terminals in at least two places--Lagos and Port Harcourt. At present, Nigeria has no fishing port. Berthing facilities are provided at the regular ports and are available only when the port is not crowded. In Lagos a small wharf which can take only one vessel at a time is provided. This inadequate berthing space forced fishing companies to build their own jetties, thus making access to fish landing statistics difficult. The other port facilities such as ice and cold stores are also privately owned by the big companies while the smaller companies buy ice and rent cold storage space from an independent firm that provides them with the services.

The reports also agreed on the need for continued biological studies in order to establish the size of available resources, the location of, and the extent of expansion that each fishery can take. Other needs identified in the reports include the need for training of fishermen, the need for collection of basic data which are further discussed later, the need for national coordination of research and development, the need for formal fisheries education and training, the need for improving fish processing, packaging, and storage, and the need for improvement of traditional methods of fishing.

If the low productivity per fisherman in the canoe component could be ascribed to the fishermen's adherence to traditional methods, lack of understanding of the belief system which governs the tradition and hence fishermen's responsiveness to innovation, lack of information on new and better fishing methods, lack of credits within the reach of fishermen, and government emphasis on production instead of on people and production then these problems could be overcome by government's investment in extension programs. Such programs should be designed to demonstrate the profitability of new fishing methods such as using a large boat that takes ten men and is mechanically propelled instead of the one-man boat which is manually operated. The programs should also be designed to provide training facilities for the use of new equipment. Processing facilities could be provided at main villages within reach of every fisherman. In addition, better packaging methods which will prolong the shelf-life of the smoked fish should be introduced. The assumption for these improvements is simply that if training and credit facilities and better processing methods are easily accessible, and if these are coupled with a feeling of concern on the part of the government, the fisherman will respond with acceptance of improved technology. Initially, though, he may want to try it just out of curiosity but if it works he will continue to use it unless it becomes less profitable than an existing or new one. Thus, the government can introduce improvements in the traditional methods of fishing.

A central problem that had plagued Nigerian fisheries has been the lack of nationally coordinated policy. Other problems include:

A. The inadequacy of the staff and facilities needed for meaningful research prevented the establishment of basic data collection.

B. Regional and state autonomy which has resulted in a lack of policy coordination, duplication of research efforts, wasteful expenditure, and in research programs not related to development needs.

C. The biological orientation of research as shown by the staff composition which has led to neglect of such variables as prices, costs, and availability of inputs, loans, credits, etc.

D. Dependence on research reports which emphasized export earnings leaving inadequately treated the questions of employment, unemployment, and underemployment of fishermen, and the provision of balanced diets for the nation.

E. Recommendations based on insufficient data or information and which, when executed, fail to achieve the projected goal. The case of fish farming in Nigeria is an example.

F. The national emphasis on crops as the main source of food without giving sufficient consideration to fish as a source of high quality proteins.

G. Lack of investigation of the marketing and distribution system of the fisheries sector to ascertain whether or not the primary producers receive an adequate share of the consumer's dollar is another deficiency. It will be difficult to ask the fisherman to increase production if the gains from such increases go to the middlemen and retailers rather than being shared equitably with the fishermen.

The Federal Government, recognizing the central problem, has established a planning division in the Federal Department of Fisheries. This planning division will recommend national fisheries policies to the government which will take action and bear responsibilities for such actions. However, before the division can recommend any policies it must evaluate several alternatives and be able to present the consequences of such alternatives (some of which could have originated from the government) to the government. It is to such policy analysis that researchers from the ministries and the universities can contribute immensely. This thesis is undertaken as part of such a contribution.

Later in this thesis we will present a research approach for policy analysis. The research approach, GSASA--general system analysis and simulation approach--is general because it can and does use many disciplines as sources of data and theory; its method of estimation is general in that it permits the use of specialized estimation techniques such as statistical estimation procedures as well as informal techniques such as guesstimates and opinions of experienced personnel. It is also general with respect to collection of data because it permits: the use of secondary data sources such as government and private records, data from previous studies and publications; the use of surveys and pilot projects; and the use of participant observations. The type of information it uses is also general. Thus, it admits the use of normative and nonnormative, and descriptive and prescriptive information. Because of its use of normative information it does not preclude value judgments. The use of these kinds of information means that the approach is philosophically general. This approach, GSASA, will be presented in detail in Chapter II.

Objectives of Thesis

The first objective of this thesis is to provide a conceptual framework for policy analysis in fisheries development. The framework will enable a researcher to identify relevant variables and, hence, the kinds of data and investigations necessary for providing information that will lead to establishing or obtaining criteria for decision making.

The second aim is to show how the framework could be used to study the Nigerian fisheries industry, using the canoe fishery component as an illustration.

The third aim is to identify and list the kinds of data required to apply the framework to the analysis of policy problems in the canoe fishery component and to develop a program for obtaining those data.

Since application of the framework will require the government to allocate resources to its execution, the fourth objective will be to examine the costs which the nation will incur and the benefits that will accrue to the nation as a result of applying the approach.

Plan of Thesis

Chapter II will consider some theoretical points in the General Systems Analysis and Simulation Approach (GSASA). Chapter III will consider a general feasibility of applying GSASA to analyze policy alternatives in fisheries while Chapter IV will present a conceptual framework for studying the Nigerian fisheries industry using the canoe component as an illustrative example. A preliminary model based on this framework will be presented in Chapter V for the canoe component. Chapter VI will discuss the need for data and data requirements in fisheries. It will also present a research plan. Chapter VII will examine the costs and benefits of using the approach presented in Chapters IV and V while Chapter VIII will summarize the thesis and draw conclusions.

CHAPTER II

GENERAL SYSTEM ANALYSIS AND SIMULATION APPROACH--THEORETICAL CONSIDERATIONS

Introduction

In the neoclassical framework of economic analysis, it is usually assumed that persons and groups that make up the economy possess perfect knowledge, perfect foresight, and hindsight. This assumption excludes the need for management ability by eliminating the existence of imperfect knowledge and, hence, the need for judgmental decisions. In the context of the theory of the firm, dropping the assumption of perfect knowledge means we no longer have perfect competition, and the firm no longer knows its demand function with certainty. When the demand function is assumed uncertain, different policies or decisions on pricing and/or output will result in different and uncertain outcomes or consequences. Baron (4), assuming a demand function to be uncertain, demonstrated that "strategies of charging a fixed price or offering a fixed quantity to the market yield different results."

In using economic analysis for solving problems of development, the researcher must therefore bear in mind the limitations imposed on inferences by the assumptions. There is no perfect knowledge in real life. Knowledge is a matter of learning, and learning requires time during which the situation and the learner could undergo change. Our tools of analysis must therefore be flexible enough to accommodate such changes. As Knight stated, "It is our imperfect knowledge of the future, a consequence of change, not change as such, which is crucial for the understanding of our problem." The investigator and the decision maker have neither complete ignorance nor perfect knowledge, the existence of which neoclassical theory assumes; what they have of knowledge exists between these two extremes and has been aptly described by Johnson (38) as degrees of knowledge.

We need knowledge of the world or environment in which we live before we can react to it. However, our reaction and/or plan of action is based on our inference of what our perception of reality means rather than on reality itself. Thus, planning in general and development in particular are activities designed to achieve a future situation from an inferred present one. If we accept the fact that our inferences are subjective interpretations of our sense perceptions, then there is need for interactions with other people concerned with planning who may have other interpretations and/or perceptions of the same phenomena. These perceptions are both normative and positive (nonnormative) and the objective is prescriptive.

In our planning or development efforts, we must infer what the future situation would have been without attempts to change it. In other words, we must be able to study an existing economic system and predict its future trend without any changes in the system or its inputs. We must then infer what changes would be brought about in the system by deliberate action designed to influence it.

This process introduces elements of error, uncertainty, and incompleteness of knowledge because it is based on our inferences of what our sense perception means. These inferences which may be biased by our culture, beliefs, and training do not guarantee complete knowledge of the real world; if they did, there would be no need for investigators to plan and anticipate future consequences of our present actions.

The use of statistical concepts recognizes the incompleteness of our knowledge of any system of interest. This recognition is achieved by the inclusion of a disturbance term in any statement of relationships. Statistical procedures then estimate the values of the parameters of the statement of relationships and/or set up hypotheses about those parameters which are tested. Probability statements are included, especially in the hypothesis testing, as an indication of the level of uncertainty the researcher is willing to accept. Probability statements can therefore be regarded as statements of belief about systems which are subject to change as more information is obtained.

The general system analysis and simulation approach recognizes the need for learning as a means of understanding an existing system; the need for processing information (available knowledge) as a means of arriving at an initial description of the system as it is, i.e., making a statement of belief based on initial information and projections. The use of projections for evaluating or studying consequences of programs, projects, and policy alternatives is an old and credible approach but the use of the computer to make projections is new. GSASA, by using computerization to compute time paths of consequences of policy alternatives, is using a new tool for an old approach. GSASA also recognizes the need for obtaining more information about the system in recognition of the incompleteness of knowledge, thus leading to a new statement of belief which is a result of analysis of the old and new information and projections; the need for interactions between investigators and decision makers as a means of resolving problems or difficulties inherent in solving developmental problems. Some of these difficulties include the absence of an interpersonally valid common denominator which can be used as a basis for maximizing "goods" and/or minimizing "bads," the absence of second order conditions which can be used for setting priorities on programs, projects, etc. Finally, GSASA recognizes the need for processing both the old and the new beliefs which include time paths of consequences of various policy alternatives with a view to arriving, through interaction between policy makers and investigators, at a refined statement of belief. The refined statement of belief can then be used as a decision rule if the level of knowledge is good enough to base a decision on. If it is not good enough, the final statement of belief is then used as existing information and the iterative process is continued. We will now show that the general system analysis and simulation approach (GSASA) is a scientific approach which, being general, can use as techniques any or all of the existing research techniques used in policy analysis.

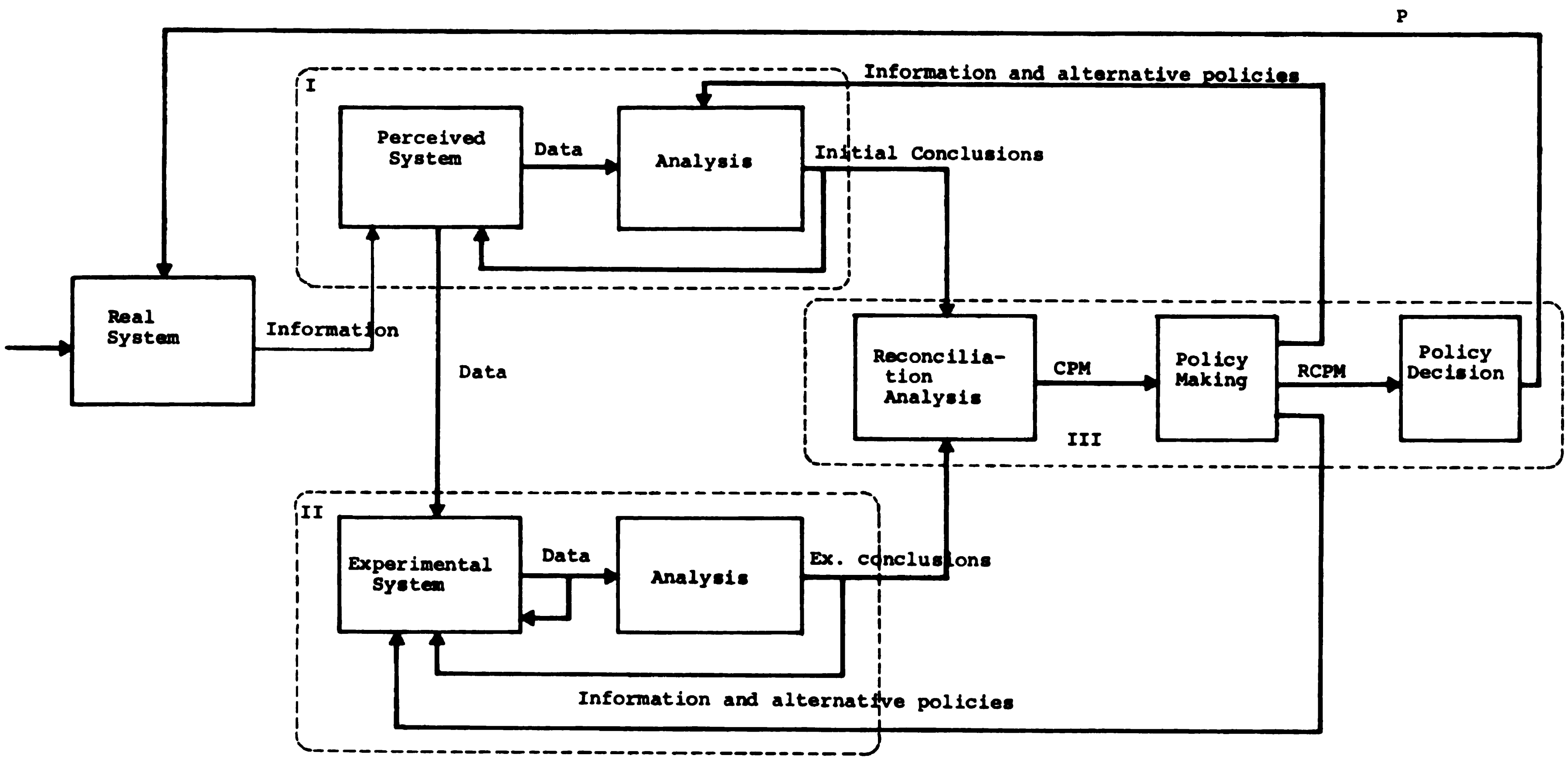
"The unity of all science consists alone in its method, not its material. The man who classifies facts of any kind whatever, who sees their mutual relation and describes their sequences is applying scientific method. . . . It is not the facts themselves which form science, but the methods by which they are dealt with" (55) and used to increase man's knowledge of his environment.

Inferences in economic research are not fundamentally different from those in other disciplines. The kinds of inferences relied on in scientific work (and which must be used, not separately, but together) were originally listed by Aristotle as deductive, inductive, and reductive. Jeffreys (36), Brodbeck (7), and Zellner (63) discussed these inferences in detail. Economists "must reason deductively as far as possible, always collating . . . conclusions with observed facts at every stage. Where the data are too complex to handle in this way, induction must be applied . . . " (41). Any one of the inferences used alone is, therefore, not sufficient to serve as the only basis for inference in a discipline. As an example, consider deductive logic which "admits only three attitudes to any proposition: definite proof, disproof, or blank ignorance. But no number of previous instances of a rule being held provides a deductive proof that the rule will hold in a new instance. There is always the formal possibility of an exception" (36). Were this not so, the Marshall plan that put Europe back on its feet after World War II could have been adapted to put LDC's on their feet. Some development economists thought so but learned otherwise. The failure of the development economists could be due to a difference in the degree of knowledge possessed about the system. In the case of the Marshall plan, the planners had an understanding of the system and correctly identified the problems, but in the case of the LDC's little attempt was made at understanding their systems as they exist; rather, knowledge of the systems was assumed. Researchers require and produce statements which recognize the existence of imperfect knowledge (if only by their use of statistical tests of hypotheses), and therefore their conclusions are less extreme than those yielded by deductive logic.

General System Analysis and Simulation Approach (GSASA)

GSASA is an approach which uses any source of information or technique appropriate for solving the problem at hand. The following diagram describes GSASA for seeking solutions to development problems (page 45).

The approach starts with the definition of a problem. That definition determines the system to be studied. The approach recognizes that there may be a difference between the real system and an investigator's perception of it. It therefore allows for such a difference by viewing the real system interacting with its environment separately from the perceived system. The



Where:

CPM = Criteria for Policy Making and E = Environment
RCPM = Refined CPM
P = Policies and programs

Figure 2.1: General System and Simulation Approach

perceived system is derived from experience with the real system. It (the perceived system) is different from the real system because of imperfections of knowledge. Studies and investigations are conducted on both the real and perceived systems. Coming out of such study efforts is a set of information (data) describing the system, as perceived, at the time its problems are defined. This initial information could include data from government or private records, previous studies of the system, on relationships derived from theoretical considerations, information from casual observations, informed individuals or from guesstimation, and from existing projections on the system. The information is then processed. Usually, the data are either time-series or cross-sectional data or a combination of both. This information is both normative and nonnormative. For example, price data are normative. The investigator, during his interactions with policy makers and their staff becomes better informed as to what is good and bad. For example, a policy alternative which concentrates wealth in the hands of a few may be considered "bad" even if it maximizes the money value of the total wealth of the society. The nonnormative or positive information includes output and production figures per man, or per year, or for a particular period of time. It may also include numbers of people who will be employed at a given target date, numbers of people who will shift from using a particular production and/or processing method to a new method, etc.

The analysis of the data and other information (in the analysis process) uses both explicit mathematical models and intuitive or mental models. This analysis would yield initial estimates both of parameters and of values of endogenous variables. These will then be used to project time paths of consequences of alternative policies, programs, and projects. The projections and the estimates will form the basis for the interaction between investigators some of whom may be itinerant researchers and consultants and the decision makers who will then have a basis for initial perception of the system. This perception or judgment is labelled "initial conclusions" in Figure 2.1. In many specialized analyses (e.g. LP, regression analysis, benefit-cost analysis), the estimates and projections form a basis for recommendations for improving the system rather than a basis for interaction and resolving of difficulties mentioned earlier. The initial conclusions in GSASA are just a part of the process of seeking solutions to developmental problems because examination of his initial perception and interaction with decision makers may lead the investigator to further investigation and interaction. He may collect more data for analysis in order to refine the initial conclusion through more interaction. This process of going back to collect more data and make new projections before coming back for more interaction is shown with a feedback of "initial conclusions" to the perceived system. When the output from "analysis" (i.e., initial conclusions) no longer changes the investigator's perception of the system, then stage I of GSASA is completed.

Stage II of GSASA starts with the setting up of a hypothetical system (labelled "Experimental System") for collection of new information, reconsideration of theoretical relationships used in the "analysis" of stage I and formulation of models which describe our perception of the real system. The models merely mimic or simulate the system, and included in the new information (labelled "Data" in stage II) are possible policy alternatives designed to solve the problems which have been defined in the "perceived system." In essence, instead of applying trial and error to the real system or even to the perceived system, it is applied to the experimental system. The data in stage II are analogous to those of stage I; the only difference is that those of stage II result from formal experiments on an experimental system (e.g. data from pilot projects) as against data from the perceived system. Analysis is carried out on the new or generated data (this happens at "analysis" of stage II). The output of analysis of stage II includes projections of time paths of consequences of programs, policies, and projects. This output is labelled experimental conclusions. The same feedback process of stage I is used in stage II, i.e., the investigator interacts with the decision makers, refines his experimental system model, obtains and analyzes new data until his experimental conclusions no longer changes his experimental model and his perception of the real system. It must be added that the experimental systems, though hypothetical, are constructed with information (data) from the perceived system.

Stage III of GSASA starts with a "reconciliation analysis." Here the results from the perceived systems (i.e. initial conclusions) are combined with information gained from experimentation (i.e. experimental conclusions) to arrive at a refined statement of belief. Coming out of reconciliation analysis is a set of criteria for policy making, or for choosing among policy alternatives, or for further interactions with policy makers. This output is labelled CPM--criteria for policy making. Usually some formula is used at the reconciliation analysis. By formula, we do not mean a mathematical relationship alone but rather a means of reconciling initial and experimental conclusions such that CPM provides guidelines for decision making. In a case where knowledge is very good, almost perfect, some of the criteria may provide a decision rule or an objective function that can be maximized or minimized. This procedure (leading to CPM) does not exclude, however, a mathematical formula. Sometimes, the information obtained at the end of experimentation leads to a reconstruction of the experimental system, hence the feedback from experimental conclusions to the experimental system. Often the CPM are at levels consistent with the goals and aspirations of the participants in the system. In such a case, the CPM outputs become information to be used as inputs in repeating stages I and II to define problems more explicitly and the entire process repeated until the goals and aspirations are fully met or it is apparent that goals must be reduced or could be advantageously increased in view of what is possible. The policy alternatives eventually chosen are then applied to the real system.

Much research work stops at the end of stage I and/or II, leaving it to the decision maker to use the information provided as he sees fit. In contrast, GSASA recognizes the need for interaction between the investigators and the decision makers and therefore goes beyond I and II to III. The whole system is thus viewed as an iterative process. That is, while the analyst who uses one of the existing techniques (e.g. benefit-cost analysis) stays within stage I (where initial conclusions now includes recommendations) and a less general simulation experiment stays within stage II, teams using GSASA combine both methods to interact with decision or policy makers at every stage in an effort to reach policy decision.

To consider a specific example, let us assume that the perceived system represents Nigerian canoe fisheries and that there is a target production per fisherman that the Nigerian government wants to achieve within a specified period of time. In reality government actions are directed at achieving more than one value. The example is to illustrate a point. With this type of situation the process of analysis starts at the point called "initial conclusions" in Figure 2.1 because the given targets are treated as the result of analysis done by government staff or their consultants. Often the targets are not given and the investigator will have to arrive at some targets through analysis and interaction. In this latter case, the process begins from E, the point of entry in Figure 2.1. GSASA is an approach that can handle either of the two cases because of its flexibility with respect to the point of beginning any problem-solving exercise.

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part of GSASA (stage I) will then be to study the Nigerian canoe fisheries as it is with a view to first understanding the structure of the fisheries as a system. This includes the study of existing production, processing and marketing, existing capital, labor and equipments, biomass availability, fishermen's attitudes to new ideas and their aspirations, existing government policies, and any other information that would help in understanding the system. Factors outside the fisheries system but which affect the system are also to be considered. Such factors include demand for fish, alternative employments opened to the fishermen, general price level of consumer goods, etc.

The next thing is to analyze the data collected. The output of this analysis will be estimates of parameters and endogerous variables and projections of time paths of criterion variables for existing programs, projects, and policies. This output will show if and when it will be possible to achieve the target production without changes in the existing programs and policies. It will also help, through interaction between the investigators and the decision makers, to determine whether a change in the system is necessary or not. As a result of interactions and analyses, new targets may be agreed upon. These new targets are therefore an output of interaction and analysis of either stage I or II.

Let F represent this output, and let our objective in stage I and/or stage II be to find what can be done to achieve F. F, in general, is a vector of targets but not just target production per fisherman. Let us further assume that the policy makers have a set of policies which are designed to achieve the targets.

The policies whose consequences the decision maker is interested in could be defined, for example, as $X_1' = [d_1, d_2, d_3, d_4, d_5, d_6]$ where X_1' is a vector of policy elements d_i, $i = 1, 2, \ldots, 6$.

The d_i's could be

d_1 = mechanization of boats

d_2 = replacement of small boats by larger boats

d_3 = subsidized petrol for fishermen

d_4 = increased prices for fish

d_5 = easy access to fish markets through improvement in transportation

d_6 = storage facilities

We can then formulate hypothetical policy alternatives as follows (only 6 of the possible combinations are used in this example):

X_{00} = a state of no change in the initial structure of the system

$X_{01} = [X_{00}, d_1]$, a state in which the first policy element is applied to the system

$X_{02} = [X_{01}, d_2]$, a state in which the first two policy elements are applied simultaneously

$X_{0i} = [X_{0(i-1)}, d_i]$, a state in which the first i policy elements are executed.

We could, therefore, define a vector of policy alternatives as

$$I' = [X_{00}, X_{01}, \ldots\ldots\ldots, X_{06}] \qquad \ldots\ldots 2.3$$

It is then possible to study the effects or consequences (in terms of who gets how much of what value--"good" or "bad") that each policy element, d_i, would have on the vector F and also to see the consequences a combination of d_i's would have. Our example considers just seven of the possible combinations. At this point, let us define $\underline{q} = \{q_{ij}\}$ as the matrix of consequences of the ith policy based on the jth initial information and where the initial information changes as a particular policy element is assumed executed.

Then $\{q_{ij}\}$ is given by

$$\underset{\sim}{q} = \begin{bmatrix} q_{11} & -- & -- & -- & -- & -- & -- \\ q_{21} & -- & -- & -- & -- & -- & -- \\ -- & q_{32} & -- & -- & -- & -- & -- \\ -- & -- & q_{43} & -- & -- & -- & -- \\ -- & -- & -- & q_{54} & -- & -- & -- \\ -- & -- & -- & -- & q_{65} & -- & -- \\ -- & -- & -- & -- & -- & q_{76} & -- \end{bmatrix} \qquad 2.4$$

This $\underset{\sim}{q}$ is the output which is represented as "experimental conclusions" in stage II of GSASA. At the point of reconciliation analysis, the $\underset{\sim}{q}$ is compared with the output (let this be $\underset{\sim}{Q}$) which is found in stage I to seek a new output, $\underset{\sim}{q}^*$. If an element of $\underset{\sim}{q}^*$ is found satisfactory it may be adopted as a goal or a target. In comparing $\underset{\sim}{Q}$ and $\underset{\sim}{q}$, a matrix of differences could be used. If a satisfactory policy or basket of policies is not found, i.e., if no element of $\underset{\sim}{q}^*$ is satisfactory, CPM could be used as information input (shown in Figure 2.1 as "information and alternative policies") into analysis of stage I. New policies could then be tried and the process repeated. At this point, refined CPM and stage II data could be used in refining the model of the experimental system. A possible choice criterion could be to choose the minimum element of CPM in the difference matrix, assuming we have a common denominator. This implies that the basket of policies that leads to a q_{ij} which is closest

to Q_{ij} is chosen for execution. This becomes more difficult if q_{ij} and/or Q_{ij} are vectors rather than scalar elements of $\underline{q}$ and $\underline{Q}$ respectively. For example, elements of $\vec{q}_{ij}$ could be protein-intake, food production, food consumption, income, and fisherman's level of satisfaction. In such a case we have multiple criteria and we can no longer use a single criterion such as "minimum element in the difference matrix" because we have no common denominator. An investigator who faces this type of situation should interact with decision makers and their staff to arrive at a common denominator. A possible common denominator for the example given above is "level of satisfaction" but because satisfaction is difficult to measure a certain level of income could be used as a proxy. If there is no agreement on a common denominator, i.e., after interaction, the investigator could pick one at random by drawing straws. Let us assume that the interaction resolved the common denominator problem, that $\underline{Q}$ represent income levels (goals) which the policy makers hope to achieve using policy tools, and that $\underline{q}$ represent income levels which could be achieved by using different policy alternatives. The choice of a policy alternative could then be based on a single criterion such as described above.

This criterion is analogous to conversion of an uncertain situation into a risk situation. In this case, the loss function $L\ (\underline{Q},d_i)$ could be evaluated at the reconciliation analysis block as the square of the difference between the initial conclusions, $\underline{Q}$ and the simulated results, $\underline{q}$. We could therefore define

$$L\ (\underline{Q},d_i) = [\underline{Q}-\underline{q}]^2 \tag{2.5}$$

The cost of taking action d_i or trying policy element d_i or basket of policies I_i is then defined as

$$R\ (\underline{Q},d_i) = E\ \{L(\underline{Q},d_i)\}$$

$$= \sum_x L(\underline{Q},d(x))\ p(x|\underline{Q}) \tag{2.6}$$

where our decision d_i is based on information X. $R\ (\underline{Q},d(x))$ is the risk function. Our criterion for choice would then be to choose, if the second order condition is satisfied,

$$\text{Min}\ [R(\underline{Q},d(x))] = \text{Min}\ [\sum_x (\underline{Q}-\underline{q})^2\ P(x|\underline{Q})] \tag{2.7}$$

where $P(x|\underline{Q})$ is the probability distribution of x given $\underline{Q}$.

Apart from a lack of common denominator with which to evaluate $R\ (\underline{Q},d(x))$ for each of the elements of $\underline{Q}$ and $\underline{q}$ we also have a problem of a lack of knowledge of the actual probability distribution. However, we may have enough information to compute confidence limits even though the information may not be enough for probability computations, i.e. enough to attach actual probability statements to each output $\underline{Q}$ or $\underline{q}$. The confidence limits on each $\underline{Q}$ or $\underline{q}$ will provide apriori information with which to interact with decision makers. The confidence limits could be the output from the "reconciliation analysis" block.

GSASA and the Bayesian Approach

GSASA presented in the above framework is analogous to the Bayesian approach of revising probabilities which is itself based on the principles of scientific method. "This process of revising probabilities associated with propositions in the face of new information is the essence of learning from experience" (63) and knowledge is a matter of learning. The Bayesian approach can be shown diagramatically as follows (page 59).

If we applied Bayes' theorem for the reconciliation analysis of our example, we would have

$$\text{Initial conclusions} = P\ (q|X_0) \qquad 2.8$$

$$\text{Experimental conclusions} = P\ (I|q) \qquad 2.9$$

In this case, we are interpreting probability statements as expressions of a researcher's degree of belief--his degree of knowledge--about the system. In addition, the researcher is assumed able to compute the cost or risk involved in his statement of belief. These statements

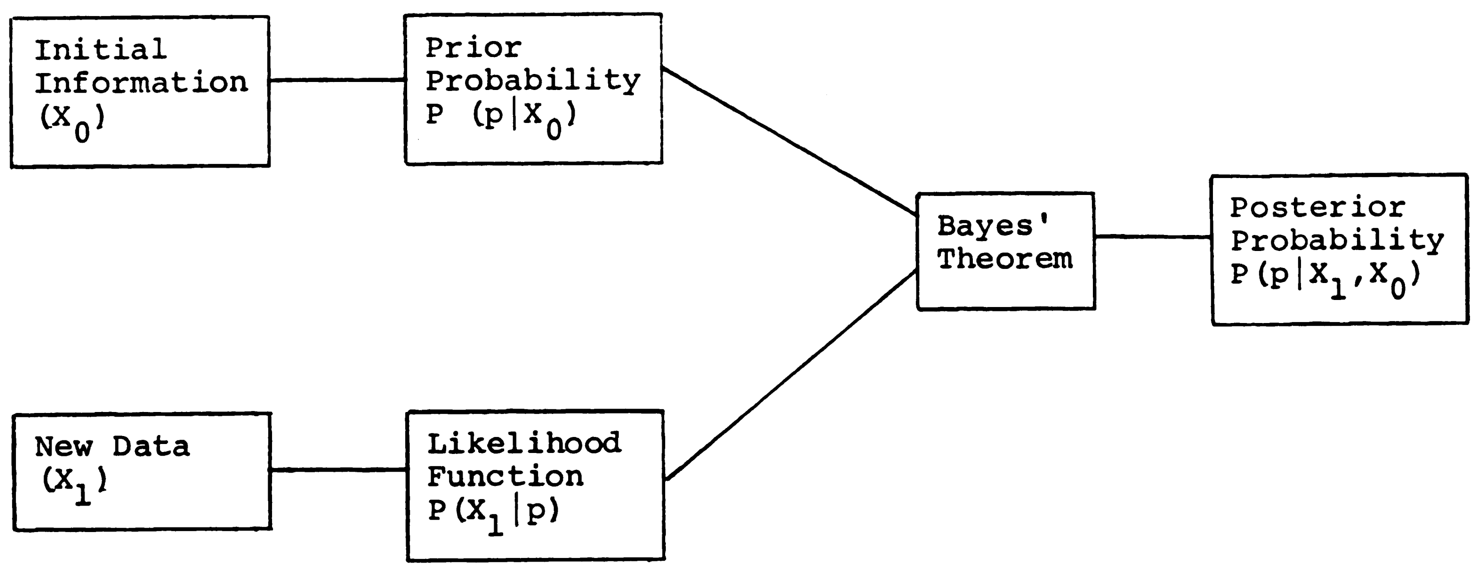


Figure 2.2: Process of Revising Probabilities[1]

[1]Adapted from (63, p. 10).

or conclusions (to use GSASA terminology) form the basis of his policy decisions. In GSASA, they form a basis for obtaining the criteria for choosing among policy alternatives. These criteria are analogous to the posterior probabilities in the Bayesian approach. CPM, criteria for choosing among policy alternatives, are multiple criteria which Bayesian approach does not deal with. Neither does it deal with the interacting process of reducing multiple criteria into a single criterion. Thus Bayes' approach cannot adequately handle policy analysis. If it could, and if CPM were a single criterion, then CPM could be defined in Bayes' terminology as

$$\underline{\text{CPM}} = \underline{P}\ (q \mid I, X_0) \qquad 2.10$$

A detailed discussion of Figure 2.2 is given in (63). Our intension here is to show the analogy between GSASA and the Bayesian approach to inference. The latter starts by obtaining initial information about the system, which is essentially the same as GSASA's data in stage I. Let X_0 denote this. Since the "fundamental idea (of probability) is that of a reasonable degree of belief, which satisfies certain rules of consistency . . .", an initial probability statement is made to indicate the researcher's degree of belief about the system. This statement is called prior probability and is analogous to GSASA's degree of belief in initial conclusions about the system's structure. Then new information is sought. The new information (or data) is processed in the light of the objective or proposition p. A statement is then made. This statement which indicates the researcher's degree of belief about the new information (analogous to "Data" of stage II, let X_1 denote this) in the light of p is called the likelihood function denoted by $P(X_1|p)$. This process is parallel to stage II of GSASA. The two probabilities $[P(p|X_0)$ and $P(X_1|p)]$ are then combined using Bayes' theorem to obtain a probability jointly determined by initial and new data. This probability is called posterior probability. The use of Bayes' theorem is equivalent to GSASA's reconciliation analysis and the resultant posterior probability corresponds to GSASA's CPM.

The difference between the two approaches is mainly in the use to which they are put, and in the additional steps taken in GSASA to reach "policy decisions." Both could be used to solve problems, but the Bayesian approach is heavily analytical and specialized on the use of one formula--Bayes' theorem--to combine the two statements of belief resulting from prior and new information while GSASA is so flexible that Bayes' theorem is but one possible formula which could be used at the reconciliation analysis process.

CPM then combines our initial conclusions, as represented by P $(q|X_0)$--a statement or our initial beliefs about the system--and our new information, embodied in stage II data and I. Our criterion for choice among policy alternatives (I) could then be to choose the combination of policies that gives the highest probability of realizing q. This choice is made in the "policy decision" block. If the highest probability, i.e., Max $\{P(q|I,X_0)\}$, is not acceptable to the decision maker as a criterion for choice because of political and economic reasons then CPM could be used as a new prior probability, seek more information (new set of I) and repeat the process until CPM is good enough to use as a criterion for choice.

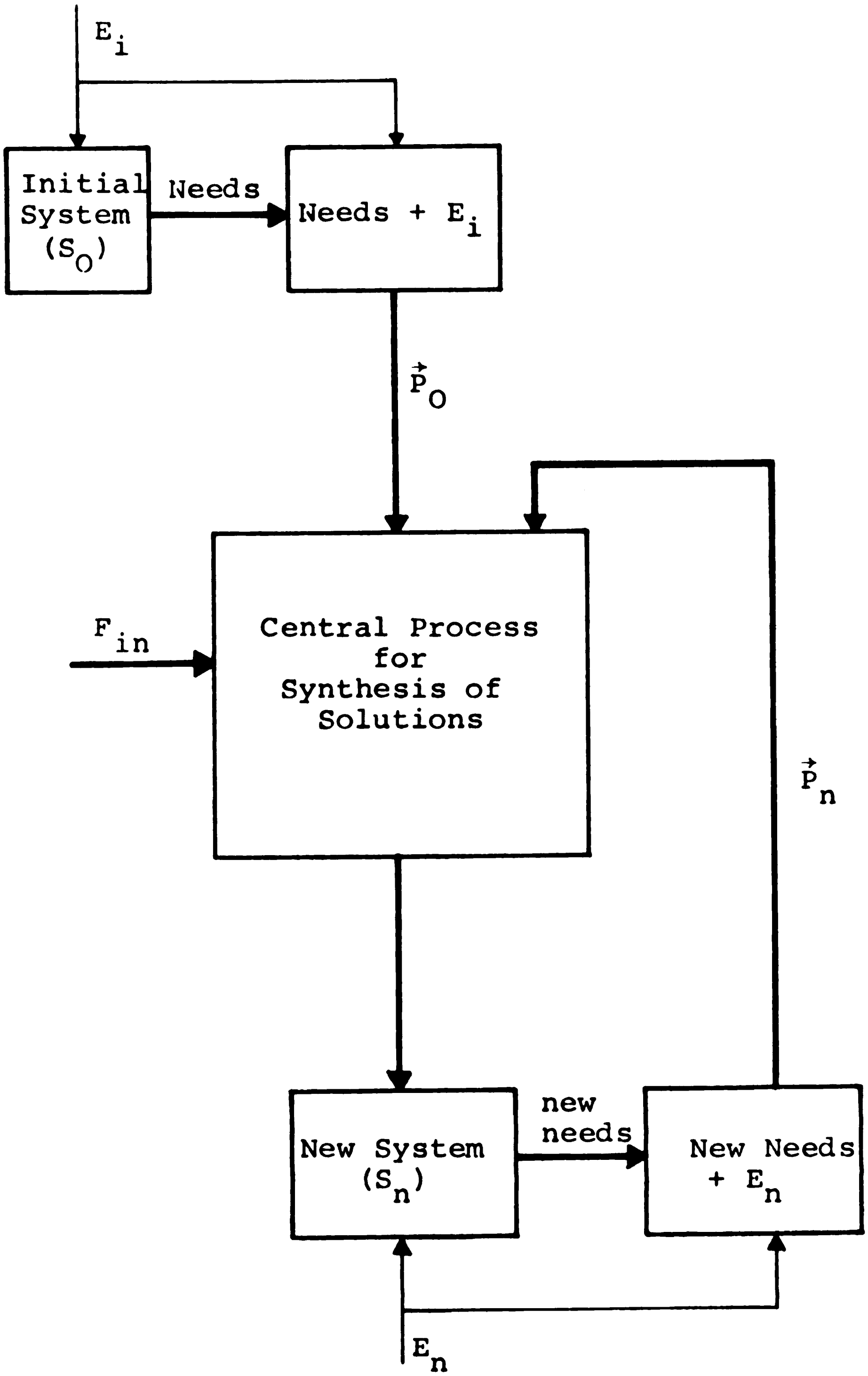
GSASA like any other problem-solving approach is a creative process because its process of model building, interaction with policy makers, search for new ideas and new ways of solving problems, etc., require originality and usefulness.

GSASA: A Creative Process

In this thesis creativity is viewed as a process which begins with the emergence of needs or problems that require satisfaction or solution, that is, "a time series of actions or events which leads to a novel (new) system that satisfies the objectives of a group (of human beings) at some point in time" (30). Model building, an art that requires originality and usefulness, is a creative process but creativity is not limited to it, it (creativity) is also found in other research activities. For example, finding a common denominator among multiple criteria and a new way of combining resource inputs for more efficient production are creative. However, our discussion of creativity will be to emphasize model building as a creative process.

Model building begins with identification of needs and problem definition. A need is a state of imbalance in the system. This state is usually caused by existence of a problem and it tends to trigger a behavior which is designed to restore the system's balance and/or create a new superior balance in an "adaptive way." Need can therefore be viewed as the cause of problem-solving activity and "problem-solving cannot be discussed adequately unless we recognize that application of knowledge in solving problems is a creative enterprise . . ." (39).

This creative process or enterprise is represented by Figure 2.3. "Initial System" (S_0) is a system which will be assumed to be in equilibrium prior to the discovery of information about its environment (E_i). When this information (E_i) is obtained the individuals in the system perceive that if they could remove certain constraints then they could have a system "better" than



Where: E_i = initial environment; E_n = new environment; $\vec{P}_O$ = initial set of problems; $\vec{P}_n$ = new set of problems; F_{in} = information used in central process; ⟶ = denote vectors.

Figure 2.3: Creative Process

the one they have now. This is then the emergence of need, the need to remove the constraints which now brings a state of imbalance to the system. Having identified the needs the individuals who perceived it initially now evaluate it within the context of the existing environment. This is an interaction between the needs and the environment and shown as (Needs + E_i) in the diagram. These individuals then proceed to seek solutions or means of satisfying the needs of the system which is now the "perceived system" of Figure 2.1. The system is then brought to the "central process" stage which embodies stages I, II, and III of Figure 2.1.

At the "central process" possible solutions are sought and synthesized through the use of existing information about the system (Fin), which includes both abstract (theoretical) and descriptive (normative and/or non-normative) and the prescriptive which is necessarily both normative and non-normative. The information is also used to construct or seek solutions to the needs. For example, the technological development of an entirely different system could be adapted or adopted; a new discovery could be made on new ways of using the existing resources of S_0; or a new interpretation of the institutional framework could be devised. All these need originality and the overcoming of inertia. The efforts here will result in a set of possible solutions to the problems and each possible solution will lead to a possible new system. At this point the consequences of the different solutions on the system will be evaluated; the evaluation is a precondition for reaching a decision rule for choosing the most desirable new system, most desirable in the sense that it satisfies the objective. S_n, the new system, represents the new state in which all the needs which, interacting with E_i, led to the imbalance in S_0 are satisfied.

When a problem is solved or an objective is accomplished the dynamic nature of man forces him to interact with his new environment (E_n) and discover new needs and thus new problems ($\vec{P}_n$) which keep the search for solutions a continuing process. This process is creative. It is creativity. Creativity can then be described as a process which addresses itself to fulfilling a need by solving a problem. As described above, it contains constructive originality and, above all, it creates a new condition (S_n) for human existence.

GSASA is an approach which encourages an investigator's creativity because it helps the investigator succeed "in conceiving of new ways of viewing physical reality, new designs for (and interpretations of) social institutions (and society's mores), new understanding of goodness and badness or new techniques and systems for deciding on right and wrong actions" (39). His new conceptions are subject to the tests for objectivity. A concept "is objective if it (a) is not inconsistent with other previously accepted concepts and with new concepts based on current experience, (b) has a clear and specifiable meaning, and (c) is useful in solving the problems with which one is confronted" (39).

Regression Models and GSASA

Many investigators, especially those whose research work is confined to stage I of GSASA and who use time series and/or cross sectional data, use linear regression models. A typical classical linear regression model which describes the real system (i.e. in the "perceived" or "experimental" system) would be represented by

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \ldots + \beta_K X_{Kt} + \varepsilon_t \qquad 2.11$$

where Y_t is the dependent variable. Often the investigator seeks to predict the future value of Y and explain its variation based on some explanatory variables--X's. These X's ($X_1, X_2, \ldots, X_K$) are usually assumed to be independent or exogenous variables. ε_t is an unobservable random variable. It is a term included in recognition of the incompleteness of knowledge. Some of the X's could be lagged values of Y. Y could represent income, consumption, expenditure on food, government investment, yield of cocoa per acre, per caput fish production or any variable that the researcher wants to investigate.

The X's represent the factors which are known or thought to affect, and assumed capable of explaining, variations in Y.

Equation 2.11 is a single-equation regression model which is used by many investigators in economic research because it is easy to estimate by the ordinary least squares method. In practice, however, much of the theory of economics is cast in the form of a system of simultaneous equations. This implies that the estimated equation such as 2.11 is only one of several equations and "when a relationship is one of several in a simultaneous system, classical least-squares estimates of its coefficients will in general be inconsistent" (28). This could be explained by the fact that some explanatory variables are jointly determined with the dependent variable and hence such explanatory variables are dependent on the contemporaneous disturbance (28, 29). Further, "the form of the (economic) functions (or relationships) is a datum" (2) which we postulate or hypothesize when we do not know it. This implies that any set of explicit simultaneous equations is but a set of hypotheses which need to be tested. This must be the case because economic theory in describing the structure of an economy does not necessarily tell us the exact structural form of the system.

Analytical techniques such as those used in statistical and econometric estimation procedures usually assume linearity; and to obtain estimates empirically we must satisfy certain assumptions about the data, the dependent and explanatory variables, and the disturbance term. It will be a premature application of the techniques if we were to use them before the assumptions are satisfied. On the other hand GSASA provides an approach which could be used to refine the data, the equations, and tools of analysis. It also permits the use of such specialized techniques as regression analysis when conditions for their use are satisfied.

Specialized Simulation Models and GSASA

The works of Von Neumann and Ulam in the late 1940's started the modern use of simulation. They used the term "Monte Carlo analysis" to describe a mathematical technique which they used to solve certain nuclear-shielding problems that were either too expensive for experimental solution or too complicated for analytical treatment. Monte Carlo analysis is used to obtain solutions to nonprobabilistic mathematical problems by simulating a stochastic process that has moments or probability distributions satisfying the mathematical relations of the nonprobabilistic problem. In the 1950's when computer use became widespread, simulation took on the meaning of experimentation with mathematical models which describe some system of interest. Such a system could be the family, the community, a national economy, or an ecosystem. This enabled social scientists to perform computerized experiments on such things as human behavior, government policies, and private investment (and disinvestment) policies or strategies. It has also been used in military training and space research. Simulation has thus become a useful tool of research.

Naylor et al. (50, 51) defined simulation as a "numerical technique for conducting experiments on a digital computer, which involves certain types of mathematical and logical models that describe the behavior of (a social or) an economic system (or some components thereof) over extended periods of realtime." Other authors have defined simulation from other points of view. For example, Clarkson and Simon (9) defined it as "a technique for building theories that reproduce part or all of the output of a behaving system." Shubik's (60) definition can be described as "operation of a model . . . which is a representation of (a) system. . . . " Orcutt (14) defined simulation as "a general approach to the study and use of models." In the context of GSASA, simulation is not just a technique of experimentation for the sake of experimentation or of building theories, but is also used in solving problems which involve the attainment of multiple objectives with limited resources. For example, a nation which strives to increase the nutritional level of its citizens by increasing their protein and calorie intakes, their levels of income in order to increase their effective demand for food and other consumer goods and which aims at reducing and/or controlling diseases by providing medical facilities has multiple objectives which must be satisfied in order to increase the general standard of living of its citizens. In analyzing policies designed to achieve these objectives it may be necessary to reduce them (the objectives) to a single objective. Such a single objective could be "Increased net income" measured in money values, thus providing a common denominator--money value of income--for analyzing policy alternatives. The attainment of such multiple objectives is a characteristic problem of developing nations. Simulation can, therefore, be described as a means of computing the time path of the consequences of alternative policies designed to attain multiple objectives.

The Naylor-type consists of nine steps and these are summarized in Figure 2.4. These nine steps were later reduced to six (e.g., 51, 49). The steps eliminated are 2, 4, and 5, but it is implicit in (49)

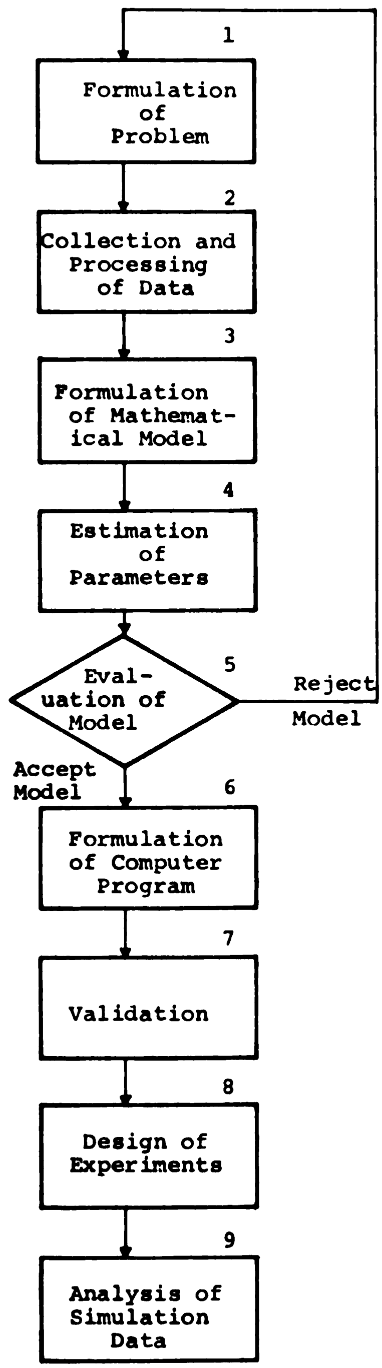


Figure 2.4: Simulation Defined as Experimentation

especially that parameter estimation (Step 4) is a prerequisite to the use of simulation. The procedures recommended for carrying out Step 4 put emphasis on analytical methods when in fact to rely on "previous theoretical or empirical knowledge about the value of parameters of the population (i.e., on a priori information) is a characteristic feature of econometric theory" (8). We would be unable to carry out Step 4 when faced with problems of insufficient data and/or faced with specification errors. In the case of insufficient data, parameter estimation techniques become impractical. For instance, suppose we have a system of simultaneous equations of the form:

$$TY + BX + U = 0 \qquad 2.12a$$

which, in the reduced form, is

$$Y = AX + V \qquad 2.12b$$

where Y is a vector of endogenous variables such as total fish catch, total processed fish, etc.; X is a vector of predetermined variables some of which could be policy variables; A is a matrix of constant coefficients and V is a vector of disturbance terms. An analytical solution for A, say $\hat{A}$ is

$$\hat{A} = (X'X)^{-1}X'Y \qquad 2.13a$$

when the ordinary least-squares method is used. When we use the generalized least-squares method we have:

$$\tilde{A} = (X'\Omega^{-1}X)^{-1} X'\Omega^{-1}Y \qquad 2.13b$$

where the variance-covariance matrix Ω is assumed known. In order to have a numerical value of $\hat{A}$ or $\tilde{A}$ we need time-series and/or cross-section data on Y and X. Without the data we could not empirically estimate the parameters, A. This implies that Step 4 cannot be carried out and since $\hat{A}$ or $\tilde{A}$ is an input to the simulation model the experiment cannot be performed.

This is not the only problem. If we assume that we could empirically estimate A, it remains constant over time and cannot be varied. Sometimes the decision maker is interested in the effects of changes in A. After all, the elements of A could be marginal propensity to save or consume, or some could be income or price elasticities. These are variables that could be affected or changed with government policies, but this process is not permitted in the Naylor-type of simulation. There is no room in this process of model formulation and empirical parameter estimation for interaction between the policy maker and the investigator. This often creates a credibility gap between the two; it also deprives the analyst of information in the hands of policy makers. Thus, this type of simulation is restricted to stage II of Figure 2.1.

On the other hand, simulation as used in the GSASA context is more flexible. GSASA policy simulation is viewed as a continuing process designed for providing information needed in decision making. It is flexible in that the initial conditions, e.g., estimates of A, need not come from empirical solution. Even when they do they could be varied depending on the policies that are being analyzed.

GSASA simulation can be used to study the effects of changes in information gathering and dissemination, organization and reorganization of firms, industries, even whole economies. This can be done by making changes or alterations in the model and observing the consequences of such changes over time. An example of such changes is implied in I of equation 2.3.

Detailed observation of the simulation system could lead to a better understanding of the system. The simulation could be used to identify and rank variables that are relevant in explaining the behavior of an economic system. Often the experience gained in building or designing a simulation model might be more valuable than the actual simulation itself. An example of this could be the pure scientists' recognition of the need to work with other scientists, e.g., economists, in order to fully understand the workings of the system. For example, the model of Nigerian canoe fisheries which we will present in Chapter IV requires the cooperation of marine biologists for the "fish growth" component, a production economist for the "harvesting" component and a marketing expert for the "distribution" component.

GSASA recognizes the need for the involvement of decision or policy makers in all aspects of research through interaction among investigators, policy makers, and their staff and consultants. The central focus of GSASA is the interaction loop where all participants in the system exchange ideas, information (both normative and non-normative) and analyses. They also evaluate research results together, ironing out differences, misinformation, etc. This is not to imply that by doing this "true" values of estimates would be found, but it would be easier to find errors and discrepancies in the interpretation of the goals and norms of the society, relationships among variables, etc. This interaction would make corrections easy to make before funds, a scarce commodity in LDC's, could be committed to projects. In addition, the interaction can force the analyst into an appreciation and understanding of all the facets of the system. The result would be conclusions that are likely to be less biased by a particular inclination such as a philosophic position or economic orientation (e.g., capitalistic or socialistic approach) and more likely to be workable within the system's framework.

GSASA and Philosophic Position

The philosophic position as a source of bias is of particular importance especially to LDC's. Any research work that disregards normative information cannot be considered very useful for solving LDC problems. An economic system is made up of communities of human beings. These communities have a system of beliefs which makes each of them a unique ethnic group. The actions and decision-making processes of each community are affected by this system of beliefs. If we can conceive of a society and evaluate its actions and decision-making processes in terms of the belief system it represents, then the understanding of its belief system becomes an avenue for understanding the economic system of the society (e.g., 39). This system of beliefs is both normative and non-normative. Information on it is included in "Data" of Figure 2.1. The normative aspects deal with what is good and bad. The question is do we, as investigators, really understand good or bad on one hand and right or wrong on the other? "Good" and "bad" are used here as adjectives to modify the word "value." When a condition, situation, or thing contributes to the attainment of human purposes, we have a good value. On the other hand when a situation, condition, or thing prevents or detracts from the attainment of human aims or purposes, then a bad value exists. "Right" and "wrong" are also used as adjectives but to modify decisions, actions, and goals or choices about actions and goals. An action or goal determined to be best in view of the non-normative and normative beliefs involved, is a right action or goal. In this context "best" means that which optimizes human interests and purposes as indicated by the value concepts involved. Among the Yoruba, for example, it is wrong to sell land, or selling land is regarded as a wrong action (an action other than a right action) because the ownership of landed property of the future generation is being given away without their consent. But the land can be leased out by the present owners (the present generation). This action (leasing the land) is viewed as right because the future generation's ownership is preserved. An investigator who fails to understand the values governing land tenure in Yorubaland and who is informed that it is wrong to sell land may conclude that the Yoruba land tenure system is not conducive to agricultural development. This will be an erroneous conclusion. It is not the ownership of the physical property (land) but the right to use the physical property that is relevant to a discussion of agricultural development with respect to the land tenure system. The Yoruba system of beliefs forbids transfer of ownership but it does not prevent the transfer of the right to use land. This example depicts how lack of understanding of the normative information can result in misinterpretation of an existing system.

Any economic development philosophy which excludes normative information (which is part of our "Data") will fail to provide a basis for reasonable problem-solving action because it has excluded from the field of relevant knowledge those types of knowledge used by decision makers whom Johnson and Zerby called "men of action" (39). The positivists, for example, exclude the possibility of normative knowledge about what is good or bad, and hence, about what is right or wrong. This implies that policy makers cannot make judgments which are at one and the same time cognitively legitimate, normative, and descriptive of the real world (39). They disallow descriptive information about what is good and bad, thus, about what is right and wrong. To them concepts dealing with the aspirations, the norms, belief systems, and all other value judgments are unobjective even when used to solve society's problems of resource allocation. But we do know that society has multiple objectives, and "rather than a single social welfare function there are many, each expressing the (positive and normative) evaluations of different groups of people. Which one (of the functions) is chosen for the purpose of solving the problem of (resource) allocation depends upon the institutional framework within which society decides upon such matters" (39). Normative information is, of necessity, a relevant part of knowledge if such knowledge is to provide a basis for choice among policy alternatives.

The fundamental rationale for using simulation in GSASA is embedded in man's uncertainty of, and his unceasing quest for, knowledge about the future. This search for knowledge, man's desire to remove or at least reduce uncertainty and be able to predict the future more accurately, is an old venture. Plato, Aristotle, Euclid, and many others used what Reichenback (56) described as "speculative philosophy" in their search for predictive power. We argued elsewhere that "reason alone does not have any predictive capacity; it gains it only in combination with observation. The predictive methods of reason are contained in the logical operations by means of which we construct an order into the observational material and derive conclusions. We arrive at predictions through the instrument of logical derivation . . . if logical derivation is to serve predictive purposes, it cannot be restricted to deductive logic; it must include methods of inductive logic" (56). If our conclusions and hence our predictions are to be of value to man's search for solutions to practical problems, then he, as the user of the results, must participate in the process of reaching such conclusions. This explains why there is a continual feedback in Figure 2.1. This process is not available in the type of simulation depicted in Figure 2.4.

GSASA and the Scientific Method

Conventionally, the scientific method consists of observation of a physical system, formulation of a hypothesis, prediction of the behavior of the system on the basis of the hypothesis, and performance of experiments to test the validity of the hypothesis. GSASA has all these steps and more.

These steps are taken in GSASA's stage I and/or stage II with "initial conclusions" (and "experimental conclusions"), which need not be numerical values, as outputs of the stages. The results of the experiments performed on the "perceived" and "experimental" systems are analyzed and summarized in the form of conclusions and/or recommendations after hypotheses have been formulated and tested. GSASA goes further than the scientific method as described above. It goes to "reconciliation analysis" where conclusions and recommendations based on data from the observation and experimentation (i.e. from the perceived and experimental systems) are combined to obtain criteria for policy making (CPM). When the criteria are not satisfactory to the policy maker, they (criteria) are fed back to the system as information input. The provision of CPM is in recognition of the fact that if economics is to play its role as the "science of administration of scarce resources in human society" (44) its method of analysis must provide the administrator with information or criteria for choosing those policy alternatives which would help him administer the scarce resources in human society.

Flexibility of GSASA

The main difference between GSASA and each of the specialized techniques used separately is that the techniques are restricted to specific models and sources of data while GSASA is not. This does not imply that they are not to be used. As a matter of fact, they may prove indispensable. Our purpose here is to show how flexible GSASA is relative to the specialized techniques.

GSASA models may include, but are not restricted to, such specialized techniques as linear programming, nonlinear programming, sets of statistically estimated simultaneous equations, and benefit-cost analysis. It (GSASA) is also flexible with respect to its data source. The specialized techniques require, in many cases, time series and/or cross sectional data to estimate parameters. Some of the techniques require data in some special form (e.g. integers). If these data are not available, these techniques cannot be used. On the other hand, the flexibility of GSASA permits the use of estimations by technical experts and "guesstimations" by experienced field staff when time series and cross sectional data are not available for parameter estimation.

Effective use of programming techniques alone for policy prescriptions is precluded unless and until the fundamental problems of a common denominator, interpersonal validity and second-order condition, and the other problems discussed in (47) have been overcome. However, programming models could be used in GSASA to represent private decision-making process.

Even though the problem of aggregation remains unsolved, programming models may sometimes be the only feasible method to determine resource allocation. For example, simultaneous allocation of several resources to a large number of activities subject to many resource and behavioral constraints can be handled easily by using linear programming. deHaen and Lee demonstrated this by using a linear programming model within a larger GSASA model (14).

Many of the underlying processes of an economic system are continuous, at least in the aggregate; but some of them are really made up of a series of discrete events. For example, fisheries population dynamics (or fish growth) is a continuous process while diffusion of innovations is a series of discrete events[1] which, in the aggregate, may be continuous. The latter may be modeled as a continuous diffusion model (47) or, at the micro level, as the discrete decisions of an individual fisherman.

Continuous processes may often be described by linear and/or nonlinear partial and ordinary differential equations. Equations 4.6 through 4.13 demonstrate how differential equations could be used to describe some of the canoe fisheries processes. The use of differential equations to describe both continuous and discrete processes within GSASA has been demonstrated by many researchers (1, 13, 14, 46, and 47). This flexibility is not available in the specialized techniques when used as the only approach for seeking solutions to development problems.

Other specialized techniques which include recursive linear programming, nonlinear programming, cost-benefit ratio analysis, critical path analysis, internal rate of return, etc., are discussed in detail

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[1]Diffusion of innovation is a discrete event because the number of farmers, fishermen or of fishing units that adopted a new idea within a period of time from other farmers or fishermen can be counted. The event occurs one at a time.

by Manetsch _et al_. (47), deHaen (13), and by deHaen and Lee (14). Instead of discussing them we will show, schematically in Figure 2.5, how some of the techniques fit into the GSASA framework. In each of the three "analysis" processes of Figure 2.1, the methods of analysis used for the specialized techniques could be used as long as the necessary conditions for their use within GSASA are satisfied. The models used in these techniques could be used to describe the processes (continuous/discrete) of the experimental system. In such modeling exercises, the investigator's perception of the real system could change. This would be an output from the block labelled "simulation." The other output would be the experimental data which go into the "Analyses" block out of which comes "initial" and/or "experimental" conclusions. The process then continues as described earlier for Figure 2.1.

The interaction among policy makers, their staff, and investigators is another source of flexibility in GSASA. This interaction promotes better understanding among people with varying cultural backgrounds, philosophic positions, and disciplines thus eliminating or minimizing bias which may be due to the differences.

GSASA, because of its flexibility, recognizes that research is a team work and, being so, uses information and theories from different disciplines in

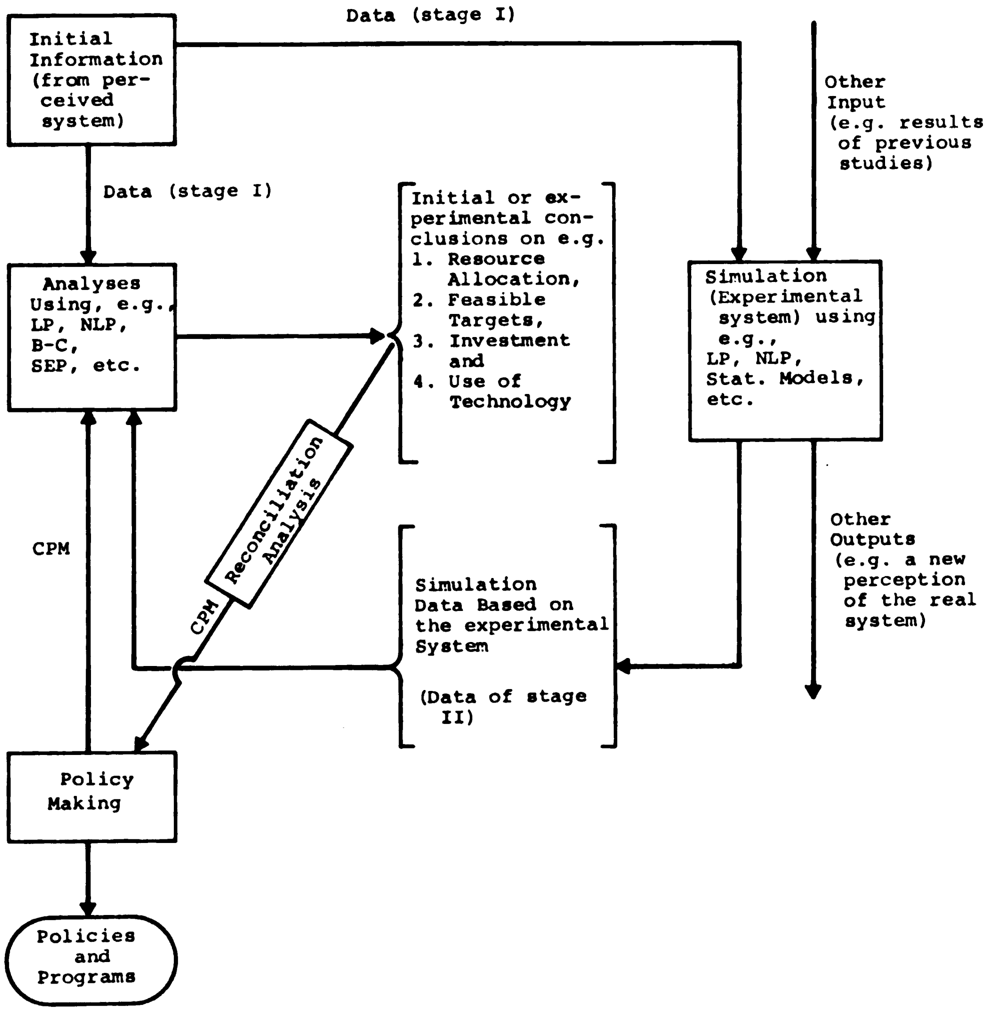

Figure 2.5: How Techniques Fit into GSASA

the search for criteria for selecting among several alternative policies, programs, or projects. The Nigerian fisheries research project which we plan to undertake exemplifies this. The project requires information and theories from economics to understand the economic factors that affect the fisheries; from biology to obtain information on resource availability, movement, and breeding patterns of fishes, and on death and spawning rates in order to determine optimal catch rate so as to avoid over-exploitation of the fisheries; from chemistry (and physics and biology) which form the core disciplines of soil science which we need in obtaining information on the introduction of new crop varieties in the fishing areas; from mathematics for model building; and from social sciences such as anthropology, sociology, psychology, etc., which form the basic disciplines on which extension training is based. Because GSASA is general or flexible all information from these various disciplines can be used to seek better understanding of Nigerian fisheries and to provide criteria for selecting the best policy among several policy alternatives.

GSASA is also flexible or general with respect to philosophic positions. It is not limited to the use of normative information like normativism, nor is it limited to using non-normative or positive information as the positivist will prefer. It allows evaluation and analysis of goals which may lead to changes in targets and yet it does not preclude accepting targets set by policy makers as a starting point for policy analysis as shown earlier in this chapter that policy analysis could begin from "initial conclusions" of Figure 2.1. This implies that like conditional normativism it (GSASA) can take values as given but unlike conditional normativism it permits analysis of values as a means of obtaining more reasonable and realistic perceptions of values. It does not insist on complete or absolute problem definition before investigation can begin; rather, problem definition is carried out iteratively as described in the section labelled "GSASA: A creative process."

GSASA is so flexible and general that it cannot be viewed as a contrast to or antithesis of the specialized techniques but as an approach which includes all the other techniques as depicted in Figure 2.5. Consequently GSASA is not a technique but an approach which embodies all specialized techniques of analysis, estimation, data collection, and the use of appropriate theories from all disciplines.

Because it is general with respect to method of analysis and computation, the use of computers or computerization does not change basically the old projection technique.

In short, GSASA is a research approach in which an iterative process is used. It recognizes the existence of a real system but because of imperfect nature of knowledge available to the investigator GSASA starts from a perceived system. It proceeds with identification of needs and an initial definition of problems as a means of defining the system and building a model of the system. From the analysis of the information collected from perceived and experimental systems, initial solutions emerge. This new information is used in redefining problems. Usually at this point new problems emerge from the new solutions. This completes the first iteration. Once the old problems are more specifically defined and the new ones are incorporated the process of seeking workable solutions continues.

GSASA is a general approach that uses many disciplines as sources of data and theory; includes the use of specialized techniques; is not biased by philosophic position; and is flexible with respect to its sources and types of data.

CHAPTER III

FEASIBILITY CONSIDERATIONS FOR DEVELOPING A GSASA MODEL OF NIGERIAN FISHERIES

The Problem

The problems of planning in LDC's are well documented in economic development literature. Because economic development planning is a social-political-economic process, it has problems of reconciling conflicting interests and aspirations of various sections of the society and of evaluating the trade-offs among numerous "goods" and "bads." To illustrate the kind of conflicts that must be reconciled, we will give an example of a conflict among three subsectors of agriculture in Northern Nigeria. The livestock people who wanted to increase beef production started a program of spraying chemicals for tsetse fly eradication. The fisheries people objected to the program on the grounds that the chemicals endanger the lives of fish in the Benue-Niger river system. At the same time, the food crop people objected to the program because it endangers the lives of consumers who might buy contaminated food crops.

The basic problem, however, which makes planning essential to the development process is the administration or allocation of scarce resources in an environment of complex interactions among physical, social, economic, and political components. These interactions involve multiple and often conflicting values including the values of income, better health services, nutrition, education, employment, price stability, etc. Policy makers who are responsible for reconciling the conflicts and administering the scarce resources need information on the possible pay-offs of different programs or projects under different policy alternatives. The problem in this thesis is therefore to find a means or a method of providing information which may lead to the establishment of a set of criteria that may help policy makers in their choice among policy alternatives. GSASA is, in this writer's opinion, an approach that could provide a means of obtaining such information for Nigeria's fisheries development planning.

Feasibility Considerations

In this section, the question we will attempt to answer is: What are the problems of Nigerian fisheries subsector and how do we approach solving them? Analysis of needs will be considered first. This will be followed with system identification, discussion of policy tools, and "apriori" realizability.

Analysis of Needs

Development economists have spent much time and energy on agricultural and/or industrial development. Their concentration on agriculture invariably led to theories of development which emphasized institutional changes, land tenure reform, transformation of traditional agriculture, diffusion of technology, and so on. This kind of concentration has not been extended to fisheries development, whereas the fishing industry, especially in less developed countries (LDS's), is a source of domestically produced food vital to balanced diet and balanced economic development.

The small per capita incomes in the LDC's must be divided up to finance all the activities of an individual. These activities include food consumption, clothing, children's education, family health, and investment in other productive activities, for example. The health budget is particularly small whereas without good health the other economic activities, food consumption included, may be impossible. There are economic costs or losses that may result from ill-health which, in many LDC's is not independent of malnutrition.

Malnutrition is now widely recognized as one of the most important health problems in emerging countries. It impedes health, working efficiency, labor or human productivity, and general economic and

social development. In this context, dietary shortage of protein, both in quantity and quality, becomes a major nutritional problem in LDC's, and particularly in Nigeria. There is evidence, in Nigeria, that there is a strong positive relationship between protein shortage and mortality of infants and toddlers (33, 43). The high mortality of children, resulting from kwashiorkor and marasmus, indicate the gravity of malnutrition problem in Nigeria (33, 34).

If we examine the Nigerian food basket per head, supply of protein per day amounts to 58.78 grams, of which only 25.37 percent comes from fish and livestock products while 57.5 percent of it comes from cereals, roots, and tubers (35). These latter categories of food are not known to contain large quantities of protein. This implies that very large quantities are consumed to provide small amount of protein. The danger, however, is in the fact that these food crops compete for land use with cash crops such as cocoa, coffee, kenaf, tobacco, groundnuts, cotton, and palm products. The tendency now is for farmers who traditionally grow food crops for sale to plant just enough for their own use and plant one of the cash crops instead. There is therefore the danger of decline in the major traditional source of protein--food crops--unless there is an increase in the effective demand for food crops. The increase must be high enough to enable food crops to compete effectively with export crops for resource allocations. If this does not happen and food prices remain unchanged there may be an urgent need for shifting the source of protein from crop to imported foods, and domestic sources other than food crops. Such domestic sources include livestock and fish products. This shift may help reduce or eliminate the high cost of malnutrition which LDC's cannot afford. These costs include (i) costs of clinically treating the malnourished; (ii) costs of child-life wastage; (iii) retardation of mental development in survivors of malnutrition and loss of efficiency in learning in malnourished children; (iv) earning and productivity loss in adult workers.

These costs include social costs to which monetary values cannot be attached easily. It may be easy to quantify the costs of clinically treating the malnourished if such cases are reported and treated. The cure itself may be accomplished by supplying the necessary balanced diet. However, most diseases and, hence, deaths are not diagnosed as being due to malnutrition. The fact is, though, that many diseases and death, particularly among children were precipitated by malnutrition (6, 10, 33, 34). For example, a child with severe malnutrition, who died of gastro-enteritis,[1] would be considered to have died of the stomach disease. Such death, especially in an LDC, should be considered as being caused by malnutrition because gastro-enteritis would probably not have been fatal, if it occurred at all, in a well-nourished child. The same is true of many deaths due to respiratory infections.

The costs of child-life wastage cannot be adequately determined in monetary terms. Among the Yoruba, for example, a child represents an insurance against old age, an economic investment for the extended family, a source of inspiration, and an accomplishment of life. To lose a child is, therefore, to lose one important essence of life and a nonmonetary value.

Another cost of malnutrition is the possible retardation of mental development in survivors of malnutrition. There is growing evidence that severe malnutrition may have a retarding effect on mental development (6, 10, 31). This may be very small on individual cases but in the aggregate it becomes sizable. At the rural or village level this may not pose a threat to development but when the pockets of poverty in the villages, towns, and cities are aggregated, then such

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[1]A disease that leads to the inflammation of the lining membrane of the stomach and the intestines.

a retardation becomes a threat to development. It is in this aggregate that we must view its effects on the nation.

It may be argued that most jobs, especially in LDC's, do not require strenuous intellectual effort, but then diminished intellectual potential which the argument condones cannot be considered insignificant to economic development. The diminished potential must have an effect on the enterpreneurship of the population and on the members responsiveness to programs and opportunities for economic development. Enterpreneurs, the existence of whom Schumpeter regarded as a necessary precondition for development, will not likely come out of a population whose mental capacity is being diminished by malnutrition; rather, they will come from people who have a balanced diet.

If economic and social development requires high-level manpower, if the existence of a population with full mental potential is required to provide the raw material for producing high-level manpower, and if availability of full mental potential can be achieved through good nutrition, ceteris paribus, then a LDC will be doing itself a favor by providing for balanced diets. Any program or project that contributes to the achievement of such a planning objective has a benefit to a nation's development. This makes provision of information for efficient planning of fisheries development in Nigeria an urgent need.

The emphasis on the mental development of a nation as a prerequisite to economic development is based on the fact that the children of today are the leaders of tomorrow; thus if a nation is to develop economically and socially the children must develop mentally with it. In malnourished children, weight and height usually fall short of genetic potential and this may lead to loss of efficiency in learning. When the learning potential of school children is reduced then it is likely that the mental potential of their nation and, hence, the nation's development prospects will also be diminished--a price too high to pay for malnutrition.

In the case of adults, malnutrition or inadequate nutrition usually results in loss of productivity and income. Berg (6) reported that in a rubber plantation in Indo-China, provision of a liberal balanced diet meals resulted in a 50 percent increase in output. Increased productivity was also recorded in Malagasy and Costa Rica after the introduction of balanced diets for workers (6). Even though it can be argued that the provision of food in the cases reported represented increased wages for workers, which resulted in increased productivity, we can also argue that the provision of balanced meals was a good investment decision on the part of the manager. The manager, we will argue, will not make the investment if the benefit from the increased production is not greater or equal to the cost of the investment in balanced meals. Whichever way we look at it the provision of balanced meals resulted in increased production and we can therefore conclude that lack of balanced diet may constitute a limiting factor of production in LDC's because it may lead to limited life expectancy, decrease in workers' productivity, lowering of workers' resistance to diseases, and increase in the rate of absenteeism which may lead to reduced production.

The provision of protein is a means of removing this limiting factor. The cost of preventing malnutrition is related to the cost of developing sources of protein--the critical nutrient for both physical and mental growth. This cost is also related to the cost of developing both the livestock and fisheries resources. In the process of developing these resources the sources of income, employment, and effective demand will also be developed. Acquisition of information on these resources is a necessary condition for effective planning for development, and GSASA provides a means of acquiring such information.

There exists a need for fisheries-oriented research in less developed countries, especially in

Nigeria. The demand for fish is growing at a much faster rate than domestic production. Consequently, fish imports are increasing at a high rate. Importation of fish would be an unnecessary drain of foreign exchange unless it is cheaper to import fish than to produce it domestically. Besides the problem of the growth of domestic demand and production, there are marketing, processing, and distribution problems. There is also the problem of inadequate research and data collection on Nigerian fisheries. The fact that the government has spent money on research, accepted foreign aid, set up training schools for fishermen, and established a Federal Department of Fisheries (the state governments established fisheries divisions with their Ministries of Agriculture) is an indication that the government recognizes the need for increasing domestic production of fish. However, we must find out if it is cheaper to sell palm oil, cocoa, groundnuts, etc. and use part of the proceeds to import fish than to produce fish.

This government's recognition of the need for increased production is not peculiar to the fisheries subsector. In fact, fisheries is only one source of domestically produced protein-rich foods. Efforts are being intensified to develop all sources of food in Nigeria, but there is a concentrated effort on food crops which are a traditional source of protein. These protein sources include legumes, meat, fish, and staple foods.

Given the soil and the climatic conditions, and human and nonhuman capital resources of the twelve states, the present pattern of domestic food production activities reflects the production situation now existing in Nigeria. The food production and, hence, the diet of the noncoastal inhabitants of the southern states--Kwara, Western, Midwestern, East Central, Southeastern, and Rivers--is based heavily on cereals and root crops. Cocoa, oil palm, timber, rubber, and other cash crops compete for the use of land and other resources in these areas. The low effective demand for food crops makes it a poor competitor against cash crops. The consequence of these is inadequate amounts of protein, at least for certain age groups. Efforts to remedy this situation include attempts to develop a poultry industry, particularly in the Western and Lagos states, a cattle industry in the north and northwestern parts of the Western State, and methods of producing, processing, and distributing local fish. Effective demand for food crops is not considered as a possible solution presently.

The development of the local fishing industry is particularly important in that it is not only a source of protein for human consumption, but fishmeal, a product of the fishing industry, is an essential input into the poultry and cattle industries. One of the questions we would like to answer is: Will it be cheaper to produce fishmeal locally or to import it?

Table 3.1 shows a projected percentage increase in demand for selected animal products and animal protein for 1975, 1980, and 1985. If we accept these figures, animal protein production must be expanded in order to achieve diets that are nutritionally adequate. The figures were computed for the use of the National Agricultural Development Committee in 1971 by the food crops subcommittee. The projection indicates that two to three times the present amount of meat produced will be required by 1985 to meet our meat demand. The increase in demand for total protein is projected as 13.7 percent while the increase for animal protein will be about 57.2 percent by 1985. This indicates a shift from other sources of protein to animal and fish products. The question now is: Will it be wise to divert limited resources to the production of animal protein (fish included) if food crops can supply the same quantity and quality of protein? The answer to this question is not simple.

In southern Nigeria, cocoyams and cassava have expanded at the expense of yams in order to make more

Table 3.1

Projected Percentage Increase in Demand* 1975/1985

	1975	1980	1985
Beef	54.7	99.6	160.0
Offals	36.5	66.4	106.6
Chicken	73.0	132.8	213.3
Mutton	54.7	99.6	160.0
Fish	60.9	110.6	181.7
Animal Protein	28.3	41.6	57.2
Total Protein	8.1	10.0	13.7

*Source: Unpublished working paper of NADC's subcommittee on food crops, Lagos, Nigeria, 1971.

labor and land available for the production of cocoa, rubber, and oil palm (33). Tobacco, kenaf, and cotton have also expanded at the expense of yams because the returns to the farmer from these crops are higher than from yam production. Traditionally, yams are grown with a mixture of, and/or in rotation with, other crops such as upland rice, maize, cowpeas, melon seed, yam beans, and vegetables. The resulting lower production of yams means also a lower production of the accompanying crops (33). Of particular interest are cowpeas, melon seed, and yam beans which are valuable sources of protein. Other causes of reduced protein production include lack of effective demand for traditional sources of protein and competition between export and domestic markets for protein-rich foods such as groundnuts and soybeans. Increasing the output of other protein rich foods such as fish may solve this problem without reducing exports.

Table 3.2 shows some of the sources of protein in four food groups: legumes, staple foods, meats, and fish. The first column gives the quantity of protein in grams per 100 grams of food. The second column gives the percentage of protein calories contained in a unit of the food. For example, 7.3 percent of the calories contained in maize are derived from protein, while in fresh fish, 60.8 percent of the calories are from

Table 3.2

Comparison of Protein Sources*

Source	Protein g/100g.	Prot.-Cal. %	Quantity of Amino Acids (mg./100g. food): Total Essential Amino Acids	Methionine	Trypto-phan	Lysine	Threo-nine	Chem. Score	Price Kobo/100g.
Legumes									
Soybean	38.0	39.4	16,339	525	532	2653	1603	66	n.a.
Melon	25.8	15.7	10,490	648	n.a.	833	1076	60	3.31
Yam bean	18.5	n.a.	7,696	352	n.a.	1258	758	66	n.a.
Cowpea	23.4	23.7	8,640	273	254	1599	842	58	1.66
Locust bean	32.3	26.3	11,844	310	289	2089	1008	56	20.00
Staple foods									
Maize	9.5	7.3	3,820	182	67	254	342	44	0.88
Milled Rice	6.7	7.1	2,695	150	n.a.	255	234	63	2.24
Parboiled Rice	7.1	7.6	3,437	268	87	261	343	73	2.24
Cassava (gari)	1.0	0.8	207	12	7	26	24	37	0.77
Yam	2.4	0.6	821	38	30	97	86	56	0.71
Meat									
Beef & Veal	17.7	29.3	7,875	478	n.a.	1573	812	70	7.94
Beef offals	16.0	47.8	7,465	376	172	1249	714	67	9.26
Chicken	20.0	42.7	8,380	502	205	1590	794	69	5.29
Mutton	15.6	21.0	6,700	383	198	1275	733	70	8.81
Mutton offals	16.0	47.8	n.a.	333	246	1357	758	n.a.	n.a.
Fish									
Fresh fish	18.8	60.8	8,465	539	n.a.	1713	861	72	6.39
Catfish, carp, etc.	18.0	80.0	8,124	665	n.a.	1590	789	69	n.a.
Mackerel	27.0	48.0	11,367	657	n.a.	2328	1067	67	3.09
Cured fish	40.0	61.3	18,281	1274	n.a.	3680	1990	71	5.79
Fish meal	75.0	87.7	30,360	2052	n.a.	5808	3180	65	n.a.

n.a. = not available

*The figures in this table are computed from Amino Acid Content of Foods (Provisional), by FAO's Food Consumption and Planning Branch, Nutrition Division, Rome, 1963; Annual Abstract of Statistics, F.O.S. Lagos, Nigeria; and "Analysis of Staple Price Behavior in W. Nigeria," Alan Thodey, doctoral dissertation, University of Illinois, Urbana, 1969.

protein. The next column gives the quantity of total essential amino acids in milligrams per 100 grams of food. This is a measure of the quality of protein contained in a given food. The next four columns give quantities of four of the essential amino acids that are considered most limiting in naturally produced food in Nigeria (33). Chemical score, next column, is considered another measure of quality of the food protein. The chemical score is computed by expressing the content of each essential amino acid in a food protein as a percentage of the content of the same amino acid in the same quantity of egg.[1] The amino acid which shows the lowest percentage is called the limiting amino acid. This lowest percentage is the chemical score. The last column gives retail price, in lieu of cost of production, in kobo[2] per 100 grams of food for each food listed.

Planning for increased production of protein-rich foods is essentially planning for increased production in three of the four subsectors of the agricultural sector of the economy. Legumes and staple foods fall into the food crop subsector, meat is the subject matter of livestock while fish belongs to the

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[1] FAO uses the amino acid composition of egg as a reference or standard.

[2] 1 kobo = .01 Naira. Naira is the Nigerian monetary unit and one Naira is equivalent to about one and one-half U.S. dollar (i.e., ₦1.00 = $1.50).

fisheries subsector. In seeking solutions to the problem of malnutrition, we must seek policies that will coordinate efforts in all the subsectors. Each food group has problems that must be considered in allocating resources for the development of the different subsectors. These problems include changes in the production patterns, competition between domestic and export markets, imports of high protein foods, employment, migration, and income problems.

It can be seen from Table 3.2 that legumes, meats, and fish are good sources of protein both in quantity and in quality. Fish rates higher than meat in protein content, protein-calorie percent, and total essential amino acid content. As a source of methionine, lysine, and threonine, fish is superior to meat. The chemical scores of meats and fish are similar. We cannot compare the protein content figures for legumes with those for meat and fish without taking the high water contents of the animal products into consideration. However, looking at the figures for cured, or partially dried fish, one sees that in this form, fish has more essential amino acids and a higher chemical score than any of the legumes.

Ideally, it would be informative to be able to include cost of producing protein from these alternative sources, but at the present state of our knowledge, we do not have such information. However, it could be argued that the cost of protein to the consumer, i.e., the price the consumer pays is the relevant information in terms of the objective of making balanced diets available at the cheapest possible cost to the consumer. The retail price which the consumer pays is such a cost. The retail price of fish is, in general, lower than that of meat per 100 grams of protein. The retail prices of most legumes, however, are much lower than the prices of fish. For example, the price of 100 grams of protein from cowpeas, which are consumed in great quantities, is 7.1 kobo, whereas 100 grams of protein from fresh fish is 33.9 kobo. However, cowpeas have a lower chemical score than fish.

The contribution of the fisheries subsector to GDP is low. In 1966/67, only 3.4 percent of the GDP came from fisheries. This relative contribution was reduced to 1.2 percent of GDP by 1971 because of the tremendous increase in crude oil production. However, in order to solve the problem of malnutrition we need protein-rich foods and the fisheries subsector can provide such food. With the changing patterns of crop production in Nigeria by which cash crops are displacing traditional sources of protein and calories, and with the projected excess demand for melon seed, maize, and yams (Table 3.1) and projected decline in production (Table 3.3), we need to develop fisheries as a primary source of protein-rich food.

In order to develop livestock (poultry included) we need feed grains and pasture. This implies that livestock will compete with cash crops for the use of land, unless grain yields expand, and compete with people for consumption of grains. But livestock is not a cheap source of calories. Over-emphasis on livestock development may create a calorie shortage. This is possible because the animal industries now being developed in Nigeria--poultry and hog production in particular--convert cereal grains into meat. If this expands without sufficient expansion in grain yields to meet both human and animal demand, the long-run effect will be a calorie shortage. We must therefore ask: Is there an alternative source of protein, in which protein production does not compete with the production of calories? Such a source is fisheries. It may be argued that soybean is an equally good source of protein. This is true, but soy bean is yet to be introduced into Nigerian cooking. When the planners introduced this crop to Nigeria, it was to be a food crop which was to be consumed locally because it is rich in protein, as can be seen in Table 3.2. However, the farmers perceived soy bean differently. They

Table 3.3

Projected Surplus in Some Selected Food Products
(1000m. tons)

Crops	1975	1980	1985
Legumes			
Soybean	11.3	23.9	40.2
Melon	0.3	0.7	-0.6
Yam bean	n.a.	n.a.	n.a.
Cowpea	125.4	264.0	445.0
Locust bean	n.a.	n.a.	n.a.
Staple food			
Maize	-51.9	-94.6	-178.6
Rice	211.6	539.1	1105.5
Cassava (gari)	501.6	931.9	1253.2
Yam	-983.9	-1771.7	-2812.1

Source: Unpublished working paper of the NADC's subcommittee on food crops, May, 1971.

accepted and adopted soy beans as a cash crop, an additional source of income. Fish does not have this problem in that it is a traditional source of protein like meat and such legumes as melon, cowpeas, etc. Agricultural development planning in Nigeria must include investigations into fisheries as a source of protein.

System Identification

Fisheries Subsector.--Fisheries is one of the four subsectors of the agricultural sector of the Nigerian economy. The others are forestry, livestock, and crops. It is, like livestock and crops, a source of food and, being so, must compete with them for production resources and the consumer's naira. Unlike them, it is the one industry and source of food in which man still plays his primitive role of hunter, though with much more complex and efficient tools. Forestry is different, but it, too, competes for land, labor, and capital. The most direct competitor for the consumer's naira is beef. These intersectoral interactions are included in the model (shown in Figure 4.1 in the next chapter) describing the fisheries sector as a system of six components. The model presented in Chapter IV is a conceptual framework which we hope will be useful in studying the structure of the industry.

In order to understand the structure of the industry, we must obtain information on its activities--harvesting, processing, marketing and distribution, and resource allocation. Specific data to be sought will include actual production per fisherman-year. This could be compared with some production goal per fisherman-year to provide an insight into the success or failure of existing policy tools designed to increase production. In addition, information must be obtained on processing methods with a view to determining the difference between total catch and the actual amount that reaches the market. This will enable us to determine the level of wastage in the processing and distribution processes. Market information on demand, village prices, and retail prices will help in the estimation of fishermen's income and hence their effective demand for consumer goods. Included in market information are costs of factor inputs such as boats, outboard engines, nets, gear, labor (hired and imputed), etc. Other variables that will be considered are essentially exogenous variables such as policy variables or environmental factors.

Choice of Canoe Component.--This study will be limited to traditional coastal fishing even though the main objective of the government is to develop the entire fisheries industry with a view to optimizing foreign exchange expenditure on fish products, to increasing protein intake per capita, and to increasing fishermen's income. After the model that will be proposed here has been tested and proven useful, the approach can be applied to study the other components which include lake, riverine, pond, trawling, and distant-water fisheries.

The choice of the canoe component as an illustrative example is due to the significant place it occupies in the domestic production of fish and to the number of people engaged in it. Some of the specific reasons for the choice are: Firstly, 63.5 percent of Nigeria's domestic fish production comes from this component and about 4 percent of the Nigerian population depend on this sector of the fishing industry and live in rural areas. Secondly, there is a growing emphasis by the government on rural development in general, and we hope that by starting this research effort on canoe fisheries, we may be able to provide some information which will help the government in its policy formulation, particularly on rural development, for the 1975/79 development plan. Thirdly, an understanding of the canoe component may lead to identification of individuals or groups of them that could be encouraged to move either vertically up to the trawling component, or to other sources of income outside the fishing industry. Finally, fishing was the main industry in most of the coastal areas of Nigeria with the exception of coastal industrial centres like Lagos, Port Harcourt, Sapele, etc. prior to the discovery and subsequent production of crude oil, construction of refineries, planned construction of fertilizer factories, etc. We may be able to identify changes in the structure of employment opportunities, alternative sources of income, and development opportunities within the fisheries industry itself. This information will, hopefully, be useful in providing criteria for directing rural development policies.

In the canoe component there are hundreds of villages along the fishing area. The population consists of Nigerians and migrants from neighboring African countries. Their fishing range hardly goes beyond two miles from the shore. A more detailed description of this component and the other components was given earlier in Chapter I.

Domestic fish production in 1970 was about 148,000[1] metric tons of which 81,000 metric tons, more than half the total, came from the canoe component. In that same year, about 40 percent of fish consumption was imported.

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[1]Knowledge about domestic production is poor. Different reports give different production figures. This and other basic data problems are discussed in Chapter VI.

A serious problem in this component concerns the labor force involved. In the area where this sector is located, the labor force was estimated as 1.41 million by the 1952-53 census (the only reliable census to date) of which 1.12 million were either full-time or part-time fishermen. The development dilemma then is, "Shall we encourage coastal trawling at the expense of the traditional coastal fishing?" If we do, we may end up with a high rate of structural unemployment. This will be a "bad" while to increase fish production per fisherman in this component may be a "good." Other "goods" include increased income for fishermen, reduction in fish prices paid by consumers, and expanded market for domestically produced consumer goods such as textile and building materials. How much of a "good" should be obtained is related to the cost of obtaining it.

Modeling Priorities.--In terms of modeling priorities within the fisheries subsector, we feel that the canoe component should be given the highest priority. The reasons for this were discussed earlier. The next component would be ponds or fish farming. In terms of production of fish the ponds component is not important. In 1970 only .05 percent of total fish production came from this component, but in terms of allocation of funds, the component becomes important. About 13 percent of all funds allocated to fisheries development in the nation is currently allocated to fish ponds. Allocation to fish ponds is higher than that allocated to the riverine component which gave about 27 percent of the total production in 1970, and the lake component which produced about 9 percent of the total domestic production of fish. In modeling the ponds component, we hope to be able to answer the question: Is this a mis-allocation of resources or are there reasons other than fish production that will justify allocating 13 percent of funds to a component that produced .05 percent of total domestic output and is not expected to produce more than .06 percent by 1985?

This will be followed with modeling of the trawling components. Presently, trawling is dominated by big fishing companies located in urban centers. It is the most logical stage to which firms in the canoe component could move as a result of technological advancement. Further, it provides an alternative source of employment for fishermen who may want to hire their labor services out for pay. It, in this author's opinion, has the greatest potential both for modernization and increased production. Modeling of the lake and riverine components will follow. We put the lowest priority on modeling the distant-water fisheries component because Nigeria does not have what can be described as distant-water trawlers at present.

Starting such a component requires heavy investment both by the government for port facilities and by the private sector for acquiring vessels and the necessary staff to operate them. In addition, international competition on the high seas is intense and there is no evidence that Nigeria has any comparative advantage over the already established Russian, American, and Japanese distant-water trawlers. It may, however, be informative to determine if development of distant-water fishing will be profitable, or if it will be cheaper to buy fish from foreign vessels and use it to produce stock fish locally, or if importing stock fish will be cheaper. We will also want to know what the impact of such a development project as distant-water fisheries will be on the other components. These and other similar questions can be addressed by GSASA.

In the preceding sections we argued that there is a need for increased production of protein-rich foods, that lack of effective demand for food crops, coupled with the expansion of cash crops, reduced the production of protein-rich foods from traditional sources. We also argued that fish could provide supplementary protein for both human consumption and animal feed. Fisheries industry was described as a subsector of the agricultural sector and we advanced reasons for our choice of the canoe component as a starting point for our study. In the following section some plausible policy tools for and the problem of fisheries development will be discussed.

Policy Tools and the Problem of Development

In order to help optimize the generation and utilization of foreign exchange and the production of fish products, the government can invest in: (1) distant water fishing on a large scale, (2) coastal trawling, (3) state management and exploitation of the lakes and the river systems, (4) construction of fishing ports and all the ancillary services that go with it. The government could also buy outboard and inboard engines and/or other inputs and help distribute them to the fishermen in the traditional sector. Petrol at subsidized prices could be used for running the motorized boats in order to increase the amount of effort put in by the local fishermen. Another possible policy alternative is for the government to employ all the fishermen and supervise their production. This will ensure a steady income to the fishermen. Various combinations of these are also possible. These by no means exhaust all the possible policy tools that could be used.

If we take the approach of a market economy, some of the possible solutions will come through the operations of the market. Generation of effective demand and the elimination of the middleman in the market system could result in increased income to the fisherman and, assuming a positively sloped supply curve, increased outputs. Improved transportation and storage facilities are essential to the reduction of wastage. The flow of information from research centers, the government, and from the market will help fishermen in their decision-making processes and such information should be made available.

If the initial capital is not available, that is, if the fisherman is unable to acquire fishing equipment and a boat, there will be no investment, which is necessary to increase both the production of fish and income to fishermen. To make capital available to the fishing industry is one possible policy tool.

Solving the problem of malnutrition will require policy tools that are designed to increase protein supply and intake. One policy tool is to increase protein supply from fisheries. There are other means apart from fish and livestock production of producing protein. One such method is to synthesize protein from natural gas. Collins (11) reported the possibility of producing protein from natural gas and claimed that about two million cubic feet of natural gas could produce about ten tons of pure protein. One advantage of the approach proposed here is its ability to analyze this as a policy alternative and compare the costs of producing ten tons of protein from fish and from natural gas. This policy can also be compared with two others, those of selling the natural gas and using the returns on producing protein from fish through fisheries development or to buy protein abroad. The consequences of such a protein production from natural gas can also be studied over time, and provide answers to such questions as: What happens to the investment in protein production if the industrial demand for natural gas leads to higher prices for natural gas? What of the question of consumer acceptability of synthesized protein? How does the economic return in using gas for protein compare with that of using it to produce chemical fertilizer? What of employment considerations in the livestock and fisheries industries? All these questions need long-term projections which our approach can provide.

In order to have a sustained growth of fish production, fishermen's income and reduced foreign exchange expenditure on fish products, there must be research on consumer tastes and preferences, quality of fish, availability of fish, performance of the market, etc. Research could therefore be an admissible component of a policy alternative designed to achieve these.

Figures 4.3 and 4.4 in the next chapter show some of these policy alternatives and how they interact.

"A Priori" Realizability

All the policy alternatives listed in the preceding section are physically realizable. Biological research efforts (16) have shown that fish production can be substantially increased without jeopardizing the fish population. There is enough capital in government and private control to carry out the investment and employment plans mentioned. There are fishing port sites for the construction of adequate fishing terminals since the delta, rivers, lakes, and the sea are physically accessible. The problem is therefore not one of physical realizability, but whether the possible policy alternatives will have the desired effect.

It is difficult to separate social, political, and economic factors when discussing realizability because they are so intertwined. Each of the plausible policy alternatives will be discussed to assess why it is or is not realizable.

The first three alternatives are essentially a government take-over of part of the fishing industry. If the government invested in industrial fishing and the coastal trawling and fishing ports, the government would be competing directly with private investors and this may be a very poor policy strategy if Nigeria is to retain her present "free enterprise" system. Government undertakings in business have had a long history of failures because of inefficiency and mal-investment. The opportunity cost to the nation of such an investment could be much greater than the benefits accruing to the nation from it. This rules out direct government involvement in the industry.

Should the government employ all the fishermen, there would be guaranteed income for them. Whether their incentive for increased production and their willingness to bear costs would be killed or not is an empirical question. The real question is: Is it feasible? Let us assume, for the moment, that the government decides to employ all the fishermen and pay each of them 15 naira ($22.50) per month. It will cost the government about 180 million naira ($270 millions) a year, exclusive of administrative costs, to operate the program. The total national allocation for the entire fisheries industry is 14 million naira ($21 million) for the 1970-74 development plan (25). Government employment of fishermen, a program that will cost about 13 times what the government plans to spend in four years, is therefore not fiscally feasible unless government revenue from fish sales is greater than or equal to the total cost incurred.

If the government provided free and/or subsidized input to industrial and coastal trawling, the existing big fishing companies may out-compete the small local fishermen. In the coastal regions of the Western, Mid-western, and Rivers States, where 80 percent of the labor force is dependent on fishing, this competition may result in structural unemployment if the fishermen are driven out of fishing. In a country where urban unemployment has long been a major problem, a policy alternative that adds structural unemployment in rural areas to the urban unemployment would be a double tragedy.

It would be a double tragedy in the sense that the program would not only fail to achieve the objective of a desired protein intake, but the unemployment that might be generated would lead to reduction in the income of some fishermen and hence in their effective demand for consumer goods. This would, in effect, result in the demand for industrial goods decreasing and in eventual reduction in government revenue which, in the course of time, would lead to a reduction in support programs for the fishing industry and hence a reduction in its production.

Furthermore, the cost of providing such free or subsidized input to a sector of the fisheries industry might be greater than the returns from the section. Consequently, government action which might result in shifting comparative advantage from the local fishing to urban-based large-scale fishing, might not be socially, politically, or economically feasible.

These assertions, negative as they are, are possible effects of the policy alternative. Whether the effects postulated here would materialize we do not know but we need to find out. Consequently, rather than dismiss this policy alternative and the others that have been or will be discussed, it would be better to simulate consequences of these policy alternatives to see if they are admissible or should be ruled out.

The fact remains, however, that the government's role should be to develop both small-scale and large-scale fishing complementarily. About 63.5 percent of the domestic production now comes from the local coastal fishing. The small-scale traditional fishing can be made more efficient if the necessary technological and institutional factors are made available. The remaining proposed policy alternatives are therefore addressed to this subsystem.

The inclusion of extension work and training, improvement in transportation systems and storage facilities in the 1970-74 development plans of the maritime states of Nigeria (Western, Midwestern, Rivers, Lagos, and South Eastern States) has given the legal and political structure which makes improvements in information flow to fishermen feasible.

The establishment of the Federal Department of Fisheries and the states' divisions, which are empowered to carry out development plans in fisheries, provides the legal and the administrative basis for implementing policy alternatives that may be found admissible.

The establishment of the Federal School of Fisheries and the subdepartments of fisheries research both at the federal and state levels is an indication that research efforts as an admissible component of a policy are feasible.

Mechanization of the canoe fisheries is another possible policy alternative. It was tried but it failed in the early 1960's. It failed because of certain limiting factors which were both human and material. The fishermen had little experience in handling mechanical equipment. The artisans who were qualified to handle outboard engines were few and could find better employment because of higher wages outside artisanal fishing. Repair and servicing facilities were not generally available except in one or two centers in a whole state. The spare parts service provided by agents for outboard engines was inadequate. Worst of all, the fishermen had neither the capital nor collateral to obtain loans to purchase outboard engines (61). The constraints could be removed by providing training facilities for fishermen, better repair, spare parts, and servicing facilities as close as possible to the fishing villages and making capital available at low cost to the fishermen. Removal of these constraints would lead to acceptability of mechanization and hence make it a feasible tool.

The fishermen are aware of the wastage in their present fishing process and have started adopting new processing techniques to reduce wastage. The problem now is to make these new techniques known and available to all the fishing villages. With an increased number of extension personnel, this is possible.

The question now is: Is it profitable to the fishermen and to the nation to embark on such a plan of action? Nigeria is a country in transition. It is the ninth largest petroleum producer in the world and fish is a preferred source of protein not only in the oil-producing areas but in the whole nation. As the oil industry grows and other industries spring up, so will the demand for fish. Presently, the demand for fish, at current prices, is far ahead of domestic production, imports have kept prices low and increased the level of protein intake. A crude estimate of the domestic fish production based on FAO and other studies gives a percentage increase of 55.9 percent in 1975-80 over 1970-75 and an increase of 30.9 percent in the period 1980-85 over the 1975-80 production. In the corresponding periods, as a result of increase in demand and in order to keep prices constant and protein intake at a reasonable level, our fish import needs (i.e., demand at constant prices minus local production) will increase 36.6 percent and 54.1 percent, respectively (53). With this increasing deficit, we need to increase fish supply if prices are to be kept at their present low levels. We could increase fish supply by increasing domestic production which may require embarking on production campaigns, or increasing fish imports, or use some combination of these two. However, we must know which of the three alternatives will be the best choice. GSASA provides an approach for examining the consequences of these alternatives and, hence, criteria for choice among them.

Nigeria, with her foreign exchange surplus and foreign aid, has the means to implement the programs. The Federal and State governments have already allocated funds for the first phase of fisheries development, and funds will continue to come as long as they are needed if we find that it will be more efficient to spend the funds to develop our resources than to spend it to pay for imports.

Summary

This chapter discussed the problem of development in general and considered the feasibility of using GSASA in a very general framework. The general feasibility consideration included analysis of needs, identification of the system, a discussion of some possible policy tools, a more detailed discussion of the problem of development, and "apriori" realizability. The next chapter will deal with a conceptualized GSASA model of Nigerian fisheries subsector.

CHAPTER IV

A CONCEPTUAL MODEL FOR THE NIGERIAN FISHERIES

Introduction

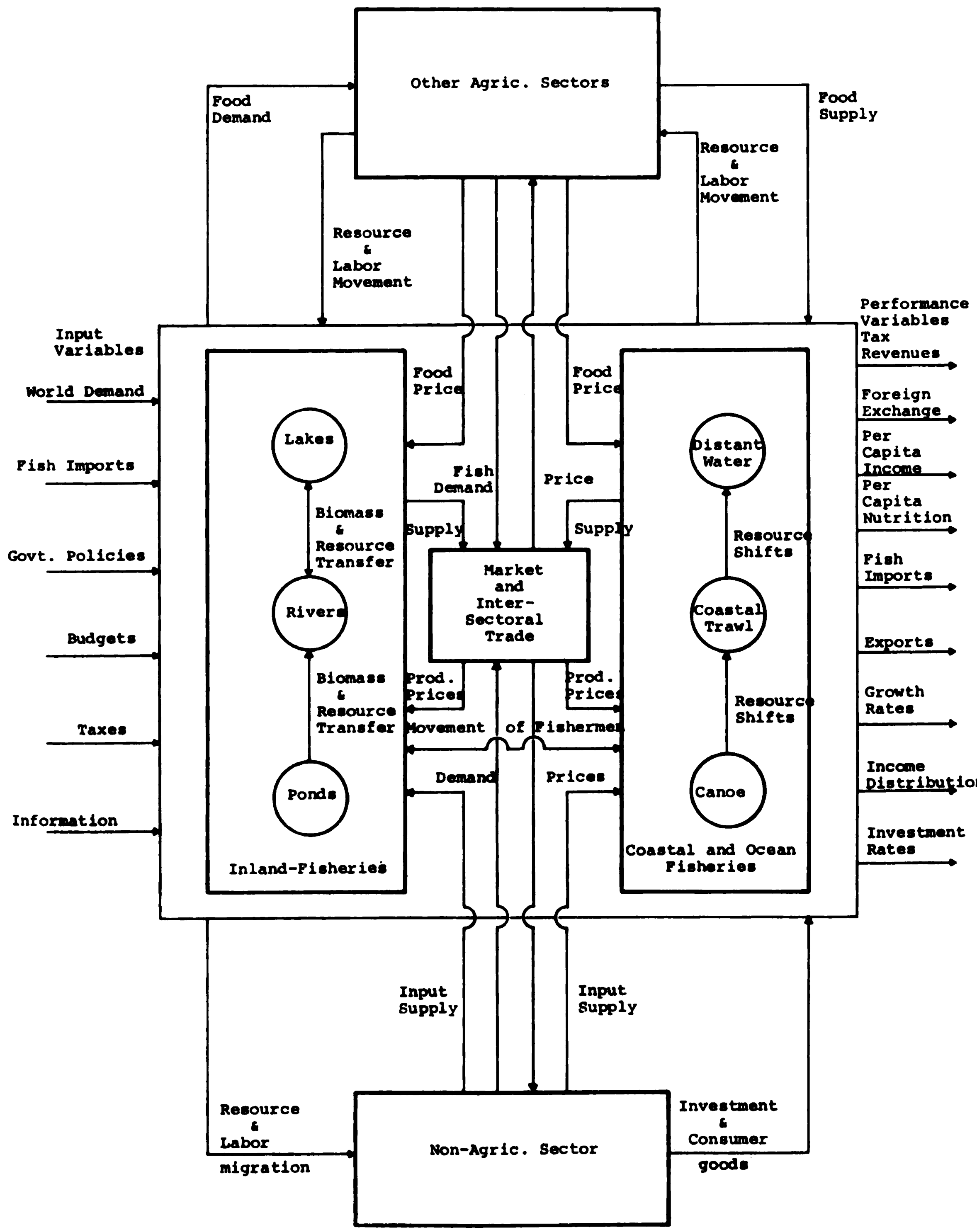
In Chapter II we discussed the theoretical basis for using the general system analysis and simulation approach. In the preceding chapter we discussed the feasibility of using this approach in studying the Nigerian fisheries sector. The conceptual model--the subject of this chapter--is viewed as a pattern for simulation models to be constructed for each component of the fisheries industry. The aim of the simulation models is to test policy alternatives (some of which were discussed in our "a priopri" feasibility considerations), project their consequences over time, and perhaps, synthesize new ones. The eventual purpose is to determine the workability, desirability, and feasibility of alternative policies and, hence, to contribute to the process of determining which policy alternatives should be followed in developing Nigerian fisheries.

The conceptual model is useful in discussions with policy makers. Presented diagramatically, it is easy to follow the conceptual flow of information, funds, and biomass. The mathematical form is more difficult to use for interaction with policy makers who may have neither the time for nor an inclination toward equations.

The Model

The model (Figures 4.1 and 4.3) depicts, graphically, the structural equations which could be viewed as an input-output system as shown in Figure 4.2. In Figure 4.2, $\vec{U}$ represents a vector of input variables some of which are shown on the left side of Figure 4.1; $\vec{Y}$ denotes a vector of performance variables shown on the right side of Figure 4.1. The internal structure of the system is only vaguely known but is conceptualized as in Figure 4.3.

From the information obtained from researchers, policy makers, and other participants in the system, we can divide the system into two subsystems (Figure 4.1): Inland Fisheries, and Coastal and Ocean Fisheries. The Inland Fisheries comprise ponds (mostly artificial), rivers, and lakes. It is logical to assume an exchange of biomass between rivers and lakes since some of the rivers drain into lakes depositing fish into them and vice versa.



1. Arrows indicate direction of resource flow.

2. "Shifts" indicate technological advancement from one level to a higher level.

Figure 4.1: Fisheries Sector

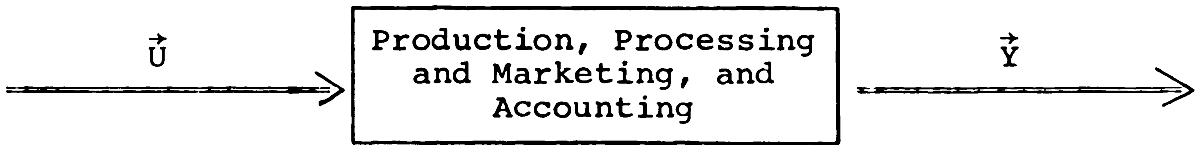


Figure 4.2: Input-Output Model

The level of technology in this sub-system is lowest for ponds in which fishing is done without the use of boats. In the rivers, especially the big rivers, boats are used but the boats are smaller than those used for fishing on the lakes where some of the boats are motorized. The level of technology on the lakes is similar to the traditional canoe component of the coastal and ocean fisheries subsystem.

Presently less than 1 percent (actually .03 percent for the West) of the canoes in the canoe section are motorized, but we envision that the level of technology here could be such that about 75 percent of the boats become mechanized--using outboard and inboard engines. The boats could then be bigger and the gear and nets correspondingly modernized. The coastal trawling, preceded by seine fishing, is the next higher stage in technological complexity while the highest level is the distant water fishing component.

The arrows in this sub-system are meant to depict the trends of development in the sense that, as the scale of operation of some of the traditional fishermen increases, they will move up to the next higher scale in the industry, i.e., canoe fishermen can become distant-water fishermen.

The interactions shown among other agricultural sectors and with nonagricultural sectors are self-explanatory. There is, however, a two-way movement of fishermen between the coastal and inland sub-systems. This became evident after the completion of the Kainji Lake when it was found that fishermen from the coast migrated to Kainji (37). It may be useful for policy formulation to study the impact, if any, of such movements.

Apart from the resource shifts within and between components of the fisheries subsector, there are opportunities, as we visualize the total economy in this figure, for labor and resource movements between other sectors of agriculture and the nonagricultural sector on one hand and the fisheries subsector on the other.

Within the fisheries subsector, a fisherman or a group of fishermen may find better income and employment opportunities in other fishing components. For example, a fisherman who operates a small boat on rivers may find it more profitable to hire his services to fishing companies in the trawling component or to join other fishermen to form a larger fishing unit in the canoe component.

Income and/or employment opportunities may also exist in crop, livestock, and forestry production. For example, farming may be more profitable for some fishermen, especially the part-time fishermen, than fishing. Introduction of swamp rice, particularly a brackish swamp variety which was successfully introduced in the Mekong Delta of Vietnam in 1965, could induce the part-time fishermen to become full-time rice farmers. Other crops that could induce such fishermen include banana, plantain, yam, cassava, and floating rice such as the one introduced to Thailand, Cambodia, and Vietnam.[1]

In the nonagricultural sector of the economy, employment opportunities may include laboring in urban centers and representing businesses supplying fishing

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[1]This information was obtained through personal interaction with my colleagues, Mr. George McDowell, who worked on the Mekong Delta Rice Project as a Peace Corps Volunteer under a USAID contract, and Mr. Bunloe Sutharomn from Thailand.

inputs to fishing communities, processing and distributing fish, supplying consumer goods to fishing communities, and so on.

The center of interaction among the three--fisheries, other agricultural and nonagricultural--sectors is the block labelled "Market and Inter-sectoral Trade." This is viewed as the center of information dissemination between fisheries and the other sectors of the economy. Understanding of this interaction will require investigations that go beyond the fisheries subsector. This point will be considered in more detail in Chapter VI.

Figure 4.3 represents the fisheries sector showing resource allocation within and between the private and the public sectors. It also looks at the decision process and information flows. It is both an overall model and a model of each of the six components. In the first case, each line represents a vector. For example, the line, actual yield, coming out of "Biomass to Users" is a vector of yields or production from ponds, rivers, lakes, canoe, coastal trawling, and distant-water fishing components. If we denote actual yield by $\vec{Q}_a$, then

$$\vec{Q}_a' = [Q_{a1}, Q_{a2}, Q_{a3}, Q_{a4}, Q_{a5}, Q_{a6}] \qquad 4.1$$

where Q_{a1} represents production or yield from ponds and Q_{a6} represents that from distant-water fishing. However,

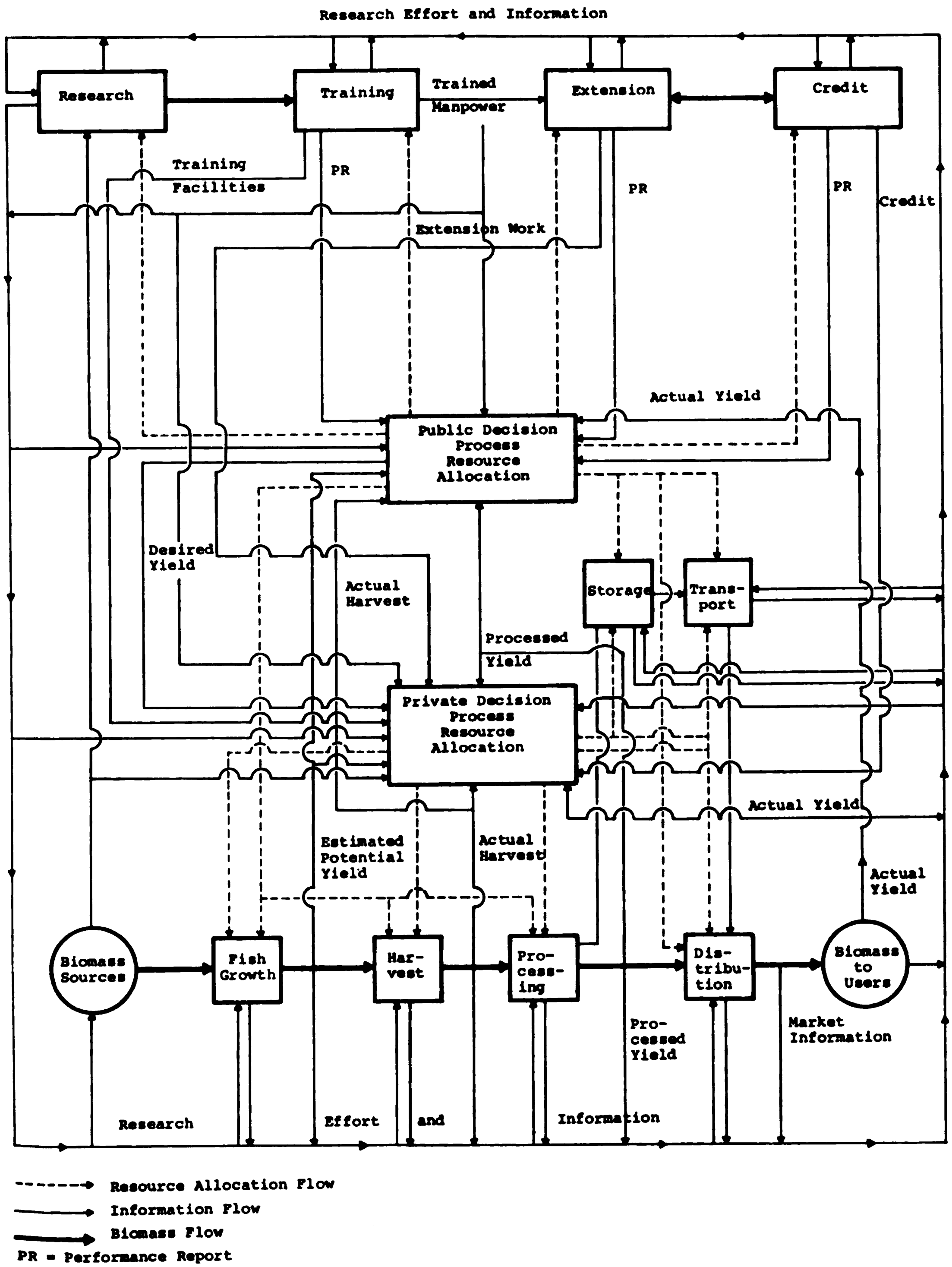


Figure 4.3: Resource Allocation and Decision Processes in the Fisheries Sector

when the model is being used to study the lakes component, the line represents only Q_{a3}.

The interdependence of the public and private decision processes and the importance of resource allocation to research, training, extension work, and credit are emphasized. The need for continuous evaluation of resource allocation and the performance of the system is shown with a feedback control (performance report) designed to assist in altering the functions of any of the public agencies to keep them up to date.

In essence Figures 4.1 and 4.3 represent the "perceived system" of Figure 2.1. Building the model of this perceived system may start with a study of the biomass source. This would take different forms depending on which component is being studied. For example, the biomass source for the coastal and ocean fisheries is the ocean. There are few policy controls other than extraction rates that would affect the breeding patterns and hence the abundance of fish in the ocean whereas the stock of fish in a pond can be more strictly controlled. Study of the biomass availability takes the form of studies of population dynamics--i.e., the growth and migration of fish in the fishing range at different times of the year--with a view to determining fishing range and types of gear and nets and mesh sizes required at any period of the year. It may be necessary at times to use zonal searches to locate fish, especially during the off-season. This would require that zonal search equipment be made available for off-season operations. If, as a result of biomass availability studies, it is found that the environment, e.g., the rivers, can support more fish than presently existing in it, a policy of fish planting may increase the biomass in such an environment. Nigerians have not yet undertaken many such studies for our rivers. Exceptions are the FAO study of the brackish water fish culture and the Rivers Niger and Benue studies (17, 18). The impact of the kind of programs recommended by the FAO on fish production can be studied with the model that is being presented here. As of now, we are almost ignorant of such impact.

After ascertaining the biomass availability, we will also want to look at the rate of growth (or decline) of the biomass. This study could be undertaken or contributed to by both the public and private sectors. Since yield is partly determined by policy, the information (this is part of what we referred to as CPM in Chapter II) obtained from such a study could be used by the public sector to design policies or regulations which will ensure the continuous availability of biomass and prevent overexploitation. The private sector can use the information on its investment and disinvestment activities. Coming out of this component is information on the estimated potential yield. The next block, labelled harvest, is the actual production process. Coming out of it is what is called "actual harvest." The difference between potential yield and actual harvest will indicate whether the biomass is over-, under-, or adequately exploited. If the potential yield is greater than actual yield, there is a case of under-exploitation which may be due to several reasons, e.g. fishermen's reaction to market conditions, inefficient production techniques, lack of capital to obtain adequate inputs, etc. If the potential yield is smaller than actual yield per fisherman, then we may have a case of over-exploitation. At this point of our knowledge of Nigerian fisheries sector, we have very little information on relative exploitation levels but GSASA provides an approach for obtaining such information and all the other types of information referred to in this discussion.

If the biomass is underexploited, we can consider changing the production function through policies involving private and/or governmental activities. The policy needed for correcting the inefficiency would be dependent on the identified cause of the inefficiency. For example, an inefficient marketing system caused by lack of access to areas of effective demand could be the reason for underexploitation.

All fish caught do not reach the market. Processing is another stage that most of the fish go through before final consumption. It has been estimated that about 70 percent of the traditional canoe fish catch are smoke-dried (19). Estimates of wastage during processing vary between 10 and 50 percent of the catch. There is no comprehensive study of Nigerian processing techniques. However, there has been an FAO study in the Midwestern State (19) and Federal Fisheries Department study of the Lake Chad Fisheries (48). The potential impact of processing techniques recommended by FAO is not known. This model should therefore be designed to analyze such impacts and relate actual harvest (or yield) to processed fish. The last block on that line analyzes the distribution patterns, transportation facilities, cost of transportation, and wastage in the transportation processes. With information from this block and on existing storage facilities, the quantity of fish available to the consumer can then be determined. This final output, labelled "biomass to users," can then be compared with potential yield (the quantity that could reach the consumers if all processes worked at 100 percent efficiency), with actual harvest, and with processed fish. The ability of this model to follow biomass from its sources to its users makes it an appropriate approach for collecting information for policy decisions. The model, being a GSASA model, can make use of all forms and sources of data.

The "private decision process" block is the focus of investment and disinvestment activities. Each fisherman (or a group of fishermen) operates a fishing unit which can be described as a firm. The firms range in size from one-man firms to firms employing several hundreds of people. The one-man canoe is an example of a one-man firm while the Ibru Fishing Company is an example of the latter. Each firm, irrespective of size, uses information from research, extension, etc. It processes the information and decides its investment or disinvestment on the basis of its analysis. The firms' activities include harvesting, processing, marketing, and transportation. Some of the big firms invest in storage facilities, training of their staff, and research. The effects on small-scale firms of such investments are not known but we hope to use this model to study such effects.

The small firms cannot afford to invest on their own independent research. They therefore rely on the public investment on research, training, extension, and credit. In order to make effective policies on these investments, the government (i.e. the public sector) requires information as to the consequences of any policy they may want to use. This model is therefore designed to provide such information. The "public decision process" is the point at which the government policy alternatives are analyzed. This block can be modeled separately, like the "private decision process," but its results can be used as exogenous input into the private decision process, the harvest, the processing, and marketing processes.

The blocks that are labelled "research," "training," "extension," and "credit" can also be modeled separately and their results used as information used in modeling the other blocks in the diagram.

This diagram, Figure 4.3, is designed to apply to any or all of the six fisheries components shown in Figure 4.1. When the diagram represents river fisheries, the biomass source is the system of rivers in the country. The firms will then be limited to river fishing units, but the government remains unchanged except that its activities only relate to river fishing. The same is true of the other five sectors. In order to apply the diagram to the entire industry, each line will be viewed as a vector of resource allocations and/or information flows. The biomass source will then be an aggregation of biomass sources. This may be too complex to model in one study.

In order to simplify the detailed discussion of this diagram, Figure 4.3, we will limit the presentation to the traditional coastal canoe fisheries i.e. the canoe component of Figure 4.1. The reasons for this choice were discussed in Chapter III.

Fish Growth

Let us take a closer look at some of the blocks in the lower part of Figure 4.3. First, consider the block labelled "fish growth." This is where we would attempt to determine the potential yield from a given biomass source. Bayagbona (5) has provided a set of equations which could be used for modeling this block. These equations will not be given here as the modeling of this block should be completed in cooperation with biologists who specialize in population dynamics. The added cost of obtaining information on fish growth, as a result of this study, will be low because the Federal Department's research efforts are now concentrated (25, 1961, 1968, 1969) in this area.

Harvesting

We now take a look at the block labelled "harvesting" in Figure 4.3. The inputs now in use are labor, canoes (small ones which also serve as the means of transportation), and traditional gear and nets. The information used comprises prices, demand information (mainly local), and canoe cost. From this we postulate the following production function and supply response equation:

$$Q = f(L,C,G,H,X) \tag{4.2}$$

$$Q^S = f(PFP,PA,K,Q) \tag{4.3}$$

where

Q = potential production for a given technology--tons/boat-day where a boat-day is a day the boat is taken out for a full day fishing

Q^S = actual production or supply--tons/boat-day

L = labor--experienced men equivalents/boat

C = size of canoe, e.g., one-man, five-man, ten-man boats

G = gear and nets--e.g., floats, local nets, nylon nets, etc., gear units

H = potential harvest--tons/boat-day

PFP = Price received by fisherman per ton of fish--₦/ton

PA = Opportunity cost to fisherman, i.e., price he will receive if he invested his resources in some other occupation--₦/year

K = cost of inputs, e.g., cost of boat, nets, hired labor, etc.

X = a vector of all other technical inputs, e.g., power for propulsion (in horsepower units), maximum fishing range of vessel (in miles), and government activities.

These two equations (equations 4.2 and 4.3) describe the technology and the production response of any sector of the fishing industry. The canoe component, which produces more than 60 percent of our domestic production, has a low technological level because most of the elements of X have zero coefficients. The question we hope to answer with this model is: Suppose we change the production function (i.e. change the zero coefficients to positive ones) by introducing new inputs, extension work, better information to fishermen, credit, etc., what will be the impact of such a change on the traditional canoe fisheries component?

Figure 4.4 is a diagramatic conceptualization of such a change. At the lower part of the diagram we visualize the present technical inputs of the canoe fisheries to consist of labor (family and hired), canoe (usually small), gear and nets (floats, hooks, and home-made nets), and transport (this is provided by the canoe). Let us assume that there is underexploitation

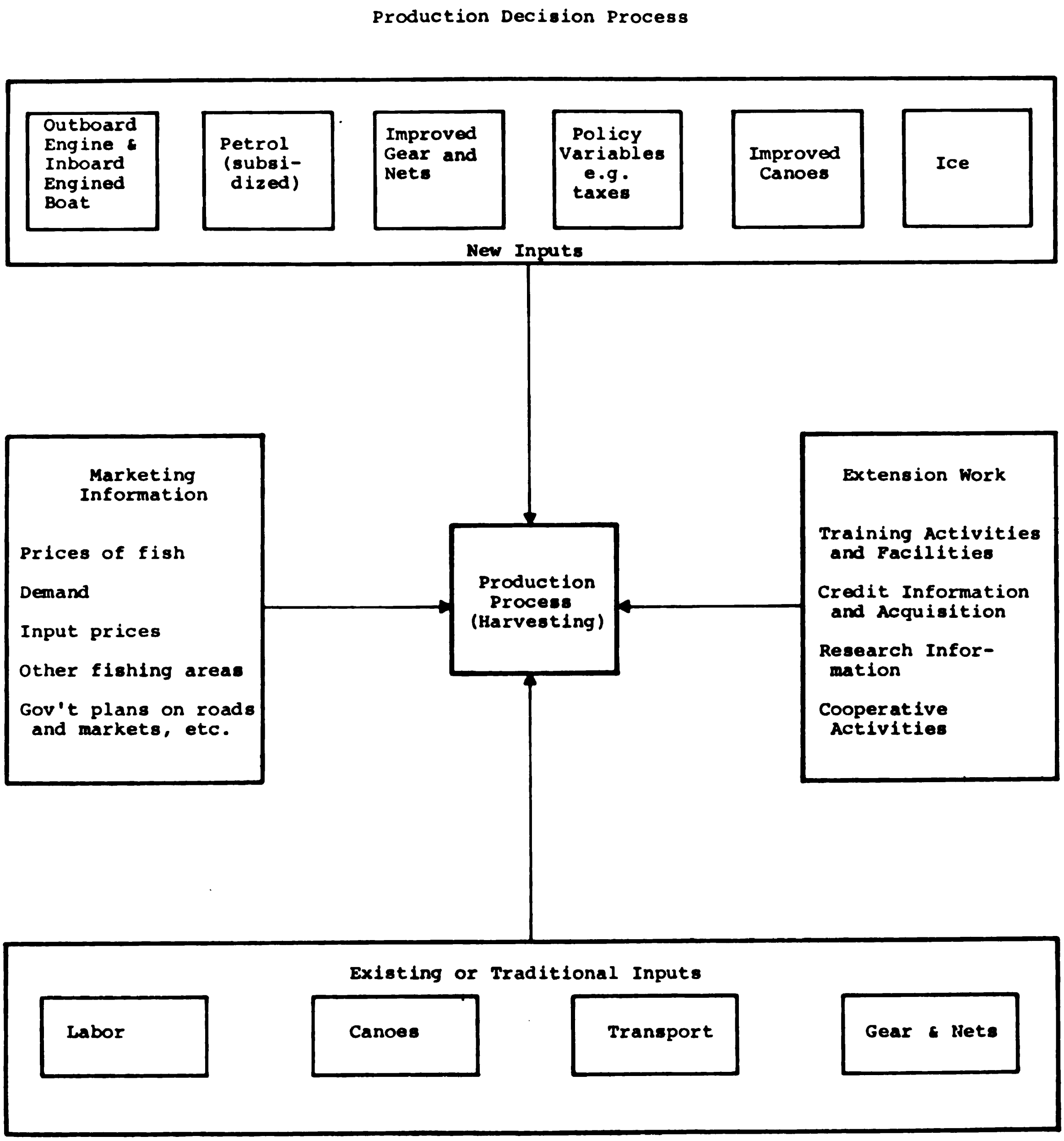


Figure 4.4: Old and New Inputs

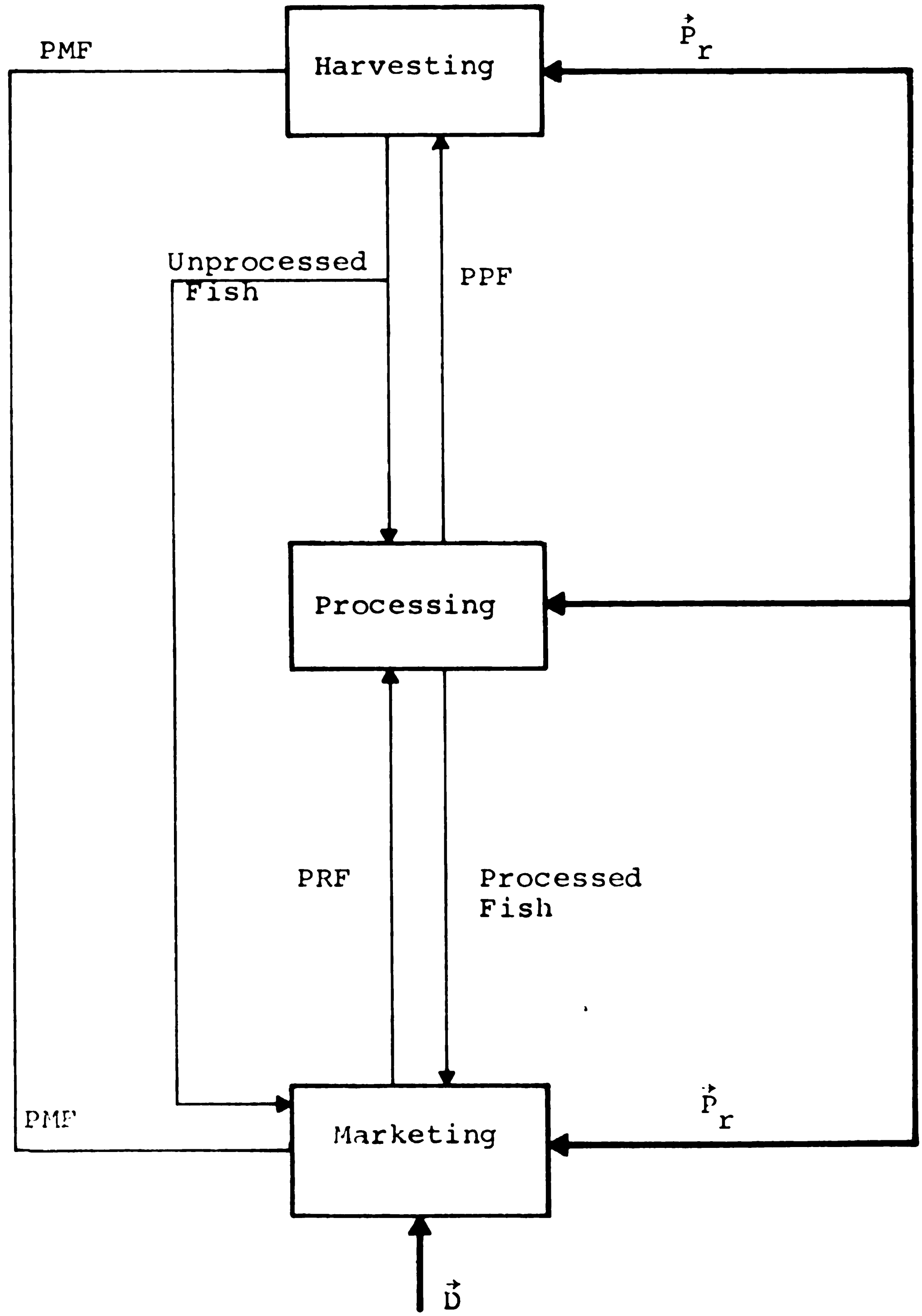
in the fisheries, i.e., the natural rate of fish growth is higher than the sum of the rate of catch and the natural rate of death. Let us further assume that this underexploitation is due to the component's low level of technology. In order to solve the problem, we introduce new technical inputs such as outboard and/or inboard engines, subsidized petrol, improved gear and nets, improved canoes, and ice plants. These new technical inputs are shown on the top part of Figure 4.4.

In order to improve the production response, better government activities are introduced. The activities include provision of market information (left center) on variables like fish prices, input prices, demand information, etc. Other governmental (and sometimes fishing equipment supply firms') activities involve extension work, training, credit information, research information, and cooperative activities (right center of Figure 4.4).

Our model can be used to test these policy tools described above and to project their consequences over time in order to obtain a set of criteria for decision making.

Describing what we mean by technological change will be quite difficult because our conception of it may not comply with the orthodox definition. Suppose we start from some given production process involving only labor and capital (capital is here used as a composite measure of canoe, gear, and nets). We could visualize many kinds of changes in this production process. Such visualization is implied in Figure 4.4. However, we may not wish to call every such change as implied in Figure 4.4 a change in technology. Some economists think of a change in technology as a change in the form of the production function, or more specifically, a change in some of its parameters. However, it seems more logical to this writer that "technology" be viewed or thought of as a separate "input element," an extra variable in the production process.

A change in technology cannot simply be a change in the amount of a certain kind of capital, or a change in the total amount of capital, defined by some index because such a change does not or cannot account for changes in the quality and/or rates of utilization of capital and labor. Consequently, changes in the rate of utilization of capital and labor, in the marketing system, in information dissemination, or in the organization of production, which increase productivity of labor and capital qualify as economic change. This visualization of a production process implies the existence of an interaction between producers (in the harvesting and processing processes) and the consumers (operating through the marketing process). This interaction is depicted in Figure 4.5.



PRP = Price received by processor

$\vec{P}_r = \begin{bmatrix} P_{rp} \\ P_{ru} \end{bmatrix} =$ retail price of processed fish
retail price of unprocessed fish

PPF = Producer price of fish

PMF = Price received by middleman

$\vec{D} = \begin{bmatrix} D_p \\ D_u \end{bmatrix}$

D_p = Demand for processed fish

D_u = Demand for fresh (unprocessed) fish

Figure 4.5: A Fishing Unit Model

In Figure 4.5, the producer uses market information on prices (e.g. retail prices of processed and unprocessed fish) in his analysis as a means of deciding how much unprocessed fish he will produce. He decides on the proportion of his catch he will process partly on the relative price of his processed and unprocessed fish. The price which the processor (when he is not the fisherman) is willing to pay for unprocessed fish is partly determined by the price of processed fish and the cost of processing. In the marketing process, we assume that prices are determined jointly by the quantity of fish (processed and unprocessed) and demand for fish.

When the quantity of fish demanded is higher than the supply, we expect prices to go up. The increased prices could induce increased supply, assuming that supply is positively related to price, and this may change the fisherman's response function and, hence, both changes in technology and economic adjustment may be observed.

Processing and Marketing

Presently we know very little about wastage, the difference between actual harvest and the amount that reaches the consumer. Based on the FAO's report (19) we can postulate the shelf-life (SL) of processed fish as a proxy for quality. This will enable us to study the output from "processing" according to quality categories and to enable us to evaluate the different processing techniques. We can, therefore, define

$$SL = f(DT, WC, HUM, TOV) \qquad 4.4$$

where

SL = shelf-life of fish

DT = drying time

TOV = type of oven

WC = water content

HUM = level of humidity

and

$$\frac{\partial SL}{\partial DT} > 0$$

$$\frac{\partial SL}{\partial WC}, \frac{\partial SL}{\partial HUM} < 0$$

If we let $Q^S(t)$ represent actual harvest at time t, then the input into the processing block is $Q^S(t)$ minus sales of fresh fish (let this be S(t)) where

$$S(t) = \alpha Q^S(t)$$

and α is proportion of actual harvest sold as fresh fish, and define $q^S(t)$ as:

$$q^s(t) = Q^s(t) - S(t) = (1-\alpha)\ Q^s(t) \qquad 4.5$$

the input into the processing block. Coming out of this block is $q_p^s(t)$, processed fish, which must be transported from the fishing villages to the market. $q_p^s(t)$ is the input into the distribution block and a percentage of loss is expected in this process; thus, we have another stage where the input, $q_p^s(t)$, is different from the output BTU(t), biomass to users.

The time delay part of the process from actual yield (or even from potential yield) can be studied by simulating the process with a kth-order distributed delay. Figure 4.6 shows a diagram of such a delay if we assume that processing and distribution are each first-order time delays.

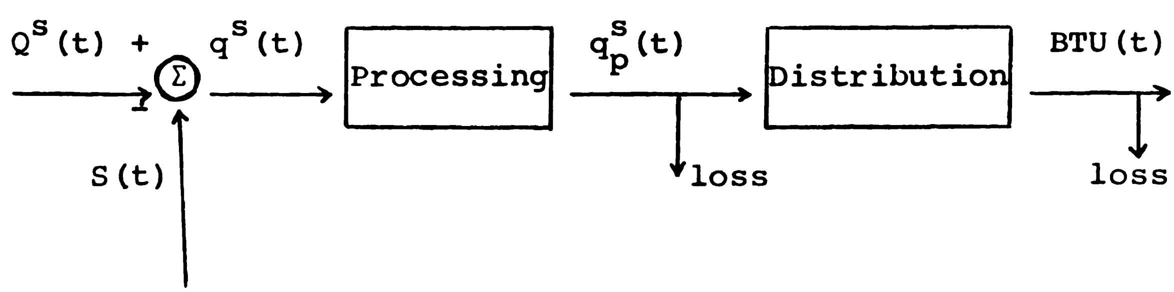


Figure 4.6: A Second Order Distributed Delay

The differential equation describing the ith stage of a kth-order delay is given by (46) as

$$D_i \frac{dr_i(t)}{dt} = r_{i-1}(t) - r_i(t) \qquad 4.6$$

Applying this to our example, where k = 2, we have

$$\frac{dq_p^s(t)}{dt} = -\frac{1}{D_1} q_p^s(t) + \frac{1}{D_1} q^s(t) \qquad 4.7$$

$$\frac{dBTU(t)}{dt} = -\frac{1}{D_2} BTU(t) + \frac{1}{D_2} q_p^s(t) \qquad 4.8$$

or

$$\frac{d}{dt}\begin{bmatrix} q_p^s(t) \\ BTU(t) \end{bmatrix} = \begin{bmatrix} -\frac{1}{D_1} & 0 \\ \frac{1}{D_2} & -\frac{1}{D_2} \end{bmatrix} * \begin{bmatrix} q_p^s(t) \\ BTU(t) \end{bmatrix} + \begin{bmatrix} \frac{1}{D_1} \\ 0 \end{bmatrix} q^s(t) \qquad 4.9$$

which is of the form

$$\frac{dr(t)}{dt} = Ar(t) + Bx(t) \qquad 4.10$$

for which numerical solutions could be obtained with

$$r(t+DT) = e^{A \cdot DT} r(t) + \int_t^{t+DT} \exp\,[A(t+DT-\lambda)]*BX(\lambda)d\lambda$$

which can be approximated by

$$r(t+DT) = r(t) + DT[A \cdot r(t) + BX(t)] + \frac{DT^2}{2} ABX(t) \qquad 4.11$$

and, if we let $(DT)^2 = 0$, expanding 4.11 we have

$$r_1(t+DT) = r_1(t) + \frac{DT}{D_1}[X(t) - r_1(t)]$$

$$r_K(t+DT) = r_K(t) + \frac{DT}{D_K}[r_{K-1}(t) - r_K(t)] \qquad 4.12$$

which, for our example, is

$$q_p^s(t+DT) = q_p^s(t) + \frac{DT}{D_1}[q^s(t) - q_p^s(t)]$$

$$DTU(t+DT) = BTU(t) + \frac{DT}{D_2}[q_p^s(t) - BTU(t)] \qquad 4.13$$

Equation 4.13 seems to be free of problems but it is not. There is more to the processing and distribution than is contained in the time delay. The assumption that each stage is a first-order delay may not be accurate. In other words, we need more information about the system than we have at present.

The blocks labelled "storage" and "transport" will have to be evaluated in terms of contributions to processing and distribution and in terms of the opportunity cost of investing in them. These blocks, like the blocks at the top part of Figure 4.3, can be modeled separately and the results from the modeling used as information input to the processes at the bottom part. This can also be done for both private and public decision processes.

The preceding conceptual model depicts the iterative process of GSASA as presented in Chapter II. It started by identifying a system which interacts with its environment (Figure 4.1) and then proceeds to conceptualize a perceived system (Figure 4.3) for which information is collected (the information flows in Figure 4.3). The information is processed at three points in Figure 4.3, namely, research, private decision, and public decision blocks. This completes stage I of GSASA. The results from the decision blocks are observed in the form of projected resource allocations to the fish growth, harvesting, processing, distribution, research, training, extension, credit, etc., blocks from public and/or private decision blocks. The research block handles experiments (stage II of GSASA) in cooperation with the public sector as shown by flows of information and resources to and from the decision-making blocks and the other blocks in the diagram. This interaction among public and private decision makers and the investigators (in the research block) is in stage III of GSASA. In this process problems of the industry are identified and defined, models are built, and criteria for policy making obtained. These are fed back to decision makers in the form of performance projections which help in the decision-making process, in the refining of policies, and in the re-defining of problems. The iterative process continues as new discoveries lead to new problems requiring different or refined criteria for choice among several alternative policies.

Mathematical Modeling

The next question we will raise is: How do we construct mathematical relationships to describe what we have presented diagramatically? There are many options. We could construct stochastic simultaneous equations, nonstochastic or exact relationships, single equations to describe single activities, etc. Then we could use econometric estimation procedures to obtain estimates of parameters and/or endogenous variables and use these to project consequences of policy alternatives. Though the use of a stochastic system of simultaneous equations and an econometric estimation procedure may be regarded as ideal by some because of the elegance of the procedures and the investigators' convictions, we will discuss problems involved in their use and argue that we should use the other methods when we cannot satisfy the conditions for their use and are justified in using other methods.

For example, let the following set of simultaneous equations describe the harvesting block of the system which we have described using diagrams:

$$Q = f_1(X_1, X_2, X_3, X_4, X_5, X_6, \vec{X}_7 | X_8, \ldots, X_n) \qquad 4.14$$

$$Q_t^d = f_2(P_r, P_m, P_g, Y, N, \varepsilon) \qquad 4.15$$

$$Q_t^s = f_3(PFP, P_a, P_g, \vec{X}_7, K, BAS, N_f, Q, \varepsilon) \qquad 4.16$$

$$Q_t^I = Q_t^d - Q_t^s \qquad 4.17$$

where:

X_1 = size of boat (denoted by gross tonnage of boat) . . . tons

X_2 = gear and nets (e.g., gillnets, setnets, hook and line, dragnets, etc.) . . . gear units/boat

X_3 = labor in man hours necessary per boat (or boat-day)

X_4 = maximum fishing range (distance of fishing village to fishing grounds) . . . miles

X_5 = power for propulsion (horsepower units per boat)

X_6 = time of year (a dummy variable to caputre seasonal variations)--e.g., rainy season, dry season

$\vec{X}_7$ = a vector of government activities (elements include, e.g., production campaign, input subsidy, information, training, research, extension, etc.) unit of measure varies for each activity

$X_8 \ldots X_n$ = variable inputs beyond control and fixed inputs that could be subjected to control (include BAS, N, N_f, BD)

P_r = retail price ($P_r' = P_r/P_g$) . . . ₦/ton

P_m = price of substitute products (e.g., beef, chicken, etc.) ($P_m' = P_m/P_g$)

P_g = general price index (proxy for inflation) . . . dimensionless

Y = level of income (GDP used as proxy) . . . ₦/year

N = population size . . . number of people

PFP = producer price (price received by fishermen (PFP' = PFP/P_g) . . . ₦/ton

P_a = price of labor from alternative activity e.g., farming ($P_a' = P_a/P_g$) . . . ₦/year

K = current capital stock (including labor) . . . in naira

BAS = Biomass availability . . . tons/year

N_f = number of fishermen . . . number

Q = total (potential) output for all fishermen . . . tons/year

Q^d = quantity of fish demanded (annual total) . . . tons/year

Q^s = quantity of fish supplied by all fishermen . . . tons/year

Q^I = quantity of fish imported (annual total) . . . tons/year (Q^I may also be determined or constrained by government policy).

' = denotes deflated prices

These equations are presented in implicit form in recognition of our lack of knowledge of the industry. Construction of explicit equations requires knowledge about the structure of the industry which is not available at this point. Explicit equations are required for policy analysis irrespective of the technique of analysis the researcher may choose to use. However, explicit sets of equations are but statements of belief, and the numerical estimates of endogenous variables, coefficients, and other parameters give but only one set of initial conditions necessary for making predictions and/or projections. There is no guarantee that the initial set of conditions obtained from conventional estimation procedure (e.g., ordinary least squares method) would be better than the set obtained either by synthetic derivations which we plan to use here for arriving at explicit equations or, as a matter of fact, from guesstimation.

In order to derive our simultaneous equations system, we will use equations 4.15, 4.16, and

$$\mu = f_4(Q, Q^d, PFP, GP, \varepsilon) = \frac{\Delta Q}{Q} \tag{4.18}$$

and define

$$\omega \equiv \frac{\Delta\mu}{\mu} \tag{4.19}$$

$$\delta \equiv \frac{\Delta Q^d}{Q^d} \tag{4.20}$$

$$\lambda \equiv \frac{\Delta Q^s}{Q^s} \tag{4.21}$$

$$\delta = \lambda \quad \text{(equilibrium condition)} \tag{4.22}$$

where:

μ = proportional rate of change in potential output

δ = proportional rate of increase of demand

λ = proportional rate of increase of supply

ω = proportional rate of increase of technological improvement (i.e., technological acceleration)

Q^* = maximum sustainable yield (tons/year)

GP = $\vec{X}_7$ = Government policies and ε = a disturbance term

Equations 4.19-4.21 are a set of simultaneous equations for which we can obtain explicit equations as follows: From equations 4.18 and 4.19

$$\omega = \frac{\Delta\mu}{\mu} = \frac{\partial\mu}{\partial Q}\frac{\Delta Q}{\mu} + \frac{\partial\mu}{\partial Q^d}\frac{\Delta Q^d}{\mu} + \frac{\partial\mu}{\partial PFP}\frac{\Delta PFP'}{\mu} + \frac{\partial\mu}{\partial GP}\cdot\frac{\Delta GP}{\mu}$$

$$+ \frac{\partial\mu}{\partial\varepsilon}\cdot\frac{\Delta\varepsilon}{\mu}$$

$$= \frac{\partial\mu}{\partial Q}\cdot\frac{Q}{\mu}\cdot\frac{\Delta Q}{Q} + \frac{\partial\mu}{\partial Q^d}\frac{Q^d}{\mu}\frac{\Delta Q^d}{Q^d} + \frac{\partial\mu}{\partial PFP'}\frac{PFP'}{\mu}\frac{\Delta PFP'}{PFP'}$$

$$+ \frac{\partial\mu}{\partial GP}\cdot\frac{GP}{\mu}\cdot\frac{\Delta GP}{GP} + \frac{\partial\mu}{\partial\varepsilon}\cdot\frac{\varepsilon}{\mu}\cdot\frac{\Delta\varepsilon}{\varepsilon}$$

$$= n_{\mu,Q}\frac{\Delta Q}{Q} + n_{\mu,Q^d}\frac{\Delta Q^d}{Q^d} + n_{\mu,PFP'}\frac{\Delta PFP'}{PFP'} + n_{\mu,GP}\cdot\frac{\Delta GP}{GP}$$

$$+ n_{\mu,\varepsilon}\cdot\frac{\Delta\varepsilon}{\varepsilon} \quad \text{(n denotes elasticity)}$$

Therefore, ω is of the form

$$\omega = \alpha_1 R_1 + \alpha_2 R_2 + \alpha_3 R_3 + \alpha_4 R_4 + \varepsilon_\omega$$

Using the same process, we can derive the equations for δ and λ to obtain

$$\omega = n_{\mu,Q}\frac{\Delta Q}{Q} + n_{\mu,Q^d}\frac{\Delta Q^d}{Q^d} + n_{\mu,PFP'}\frac{\Delta PFP'}{PFP'} + n_{\mu,GP}\cdot\frac{\Delta GP}{GP}$$

$$+ \varepsilon_\omega \qquad 4.23$$

$$\delta = n_{Q^d,P_r'}\cdot\frac{\Delta P_r'}{P_r'} + n_{Q^d,P_m'}\frac{\Delta P_m'}{P_m'} + n_{Q^d,Y}\frac{\Delta Y}{Y} + n_{Q^d,N}\cdot\frac{\Delta N}{N}$$

$$+ \varepsilon_\delta \qquad 4.24$$

$$\lambda = n_{Q^s,PFP'} \cdot \frac{\Delta PFP'}{PFP'} + n_{Q^s,P'_a} \cdot \frac{\Delta P'_a}{P'_a} + n_{Q^s,\vec{X}_7} \cdot \frac{\Delta\vec{X}_7}{X_7}$$

$$+ n_{Q^s,K} \cdot \frac{\Delta K}{K} + n_{Q^s,N_f} \cdot \frac{\Delta N_f}{N_f} + \varepsilon_\lambda \qquad 4.25$$

These equations (4.23-4.25) can be written as:

$$\omega = \alpha_1 R_1 + \alpha_2 \delta + \alpha_3 R_2 + \alpha_4 R_3 + \varepsilon_\omega$$

$$\delta = \beta_1 R_3 + \beta_2 R_4 + \beta_3 R_5 + \beta_4 R_6 + \varepsilon_\delta \qquad 4.26$$

$$\lambda = \delta_1 R_2 + \delta_2 R_7 + \delta_3 R_8 + \delta_4 R_9 + \delta_5 R_{10} + \varepsilon_\lambda$$

$$\delta = \lambda$$

which shows a familiar set of simultaneous equations in the reduced form:

$$Y = -T^{-1}BX - \quad ^{-1}U = AX + V \qquad 4.27$$

In this form we could use conventional econometric approach to obtain numerical estimates of the elements of A and hence estimates of Y both of which would have given us initial conditions needed to project demand and supply response over time using, for example,

$$Q_t^d = Q_0^d e^{\delta t}$$

or 4.28

$$Q_t^d = (1+\delta)Q_{t-1}^d$$

and

$Q^s_t = Q^s_o e^{\lambda t}$

or 4.29

$Q^s_t = (1+\lambda)Q^s_{t-1}$

and from 4.28 and 4.29 we can compute our import needs as $Q^d_t - Q^s_t$ at time t.

This approach limits us to only one value or estimate of δ and of λ and there will be no basis for varying them. Another problem, perhaps, most important now, is that we have neither cross-sectional data nor time series data on X or Y. There are other problems which will be discussed in the next section called "Use of nonstochastic or exact equations." Meanwhile, we will view the problems from a different perspective. For instance, we can go back to equations 4.23 and 4.25 and use (a) informed guesses to obtain initial values of the elasticities and the rates of increase, and (b) a set of possible policies that would increase λ and, hence, Q^S over time. This approach may not solve our problem either. Even if we assume constant values for elasticities, we could still have endogenous variables, e.g. prices, population, income, etc., to deal with. One solution is to generate the values of the endogenous variables within the system.

Since different policies will generate different sets of consequences over time, GSASA will help in selecting policies before funds are committed to their execution. The iterative process of GSASA permits the investigator to start from relatively uncertain knowledge about the system, its problems, and policies; proceed gradually to define problems more explicitly as he obtains more information about the system; perform experiments as means of obtaining more information; build better models to test policy alternatives as his knowledge improves; analyze consequences of policy alternatives by using his model; obtain criteria for choice among several alternatives; and, finally, to help make policy, program, and project choices. He may discover new problems or better interpretation of existing tools or even new ways of using existing policies; this leads to a continuation of his search for different criteria and, hence, the iterative process continues.

Use of Nonstochastic Equations

In the preceding sections, we tried to raise some of the problems that may make using simultaneous equations systems and distributed delays difficult. We also showed that it is possible to construct a stochastic system of equations to describe the fisheries.

But we feel that our present knowledge about the fisheries industry is not adequate enough to use stochastic equations and that we can justify the use of exact equations.

The relationships given in the preliminary model (Chapter V) are of a nonstochastic, or so-called "exact" nature. This means that the equations do not have the final form (e.g. equations 4.26) which is desirable, or perhaps necessary, for the purpose of statistical estimation and/or hypothesis testing. If the distributions of the ε's are known, then we could use Monte-Carlo type of simulation. However, we do not know the probability distributions of the ε's. It could be argued that this is a particularly serious short-coming of using exact equations, as the introduction of stochastic elements is, perhaps, the key to clearer understanding of an economic process. Before a justification of the use of exact relationships is made, let us briefly consider some of the essential stochastic elements.

There are various types of risk elements that are relevant to the behavior of the individual fisherman as he invests in fishing activities. Some of these elements are associated with future values of prices, with outputs resulting from given inputs, and with other variables (e.g. credit, training, and storage facilities), which are data in the calculations of the individual investor. If the information about the future values of the data is given in the form of certain probability distributions, it is possible to develop a probability calculus for prospective catches, prices, etc. The procedure is simply to specify the form of the relevant probability distribution by starting from the assumption that there is some dependence, in a stochastic sense, between the past and the future. This dependence is such that the fisherman's data of the past become parameters of the probability distributions of the future data. At this point, we must distinguish between such stochastic schemes as the fisherman has knowledge of, believes in, or actually uses (i.e. the scheme the fisherman believes to be the true scheme or probability), and the more complete or "certain" schemes that would represent "all that anybody could know" about the future (i.e. a state of more or even near-perfect knowledge).

The fundamental econometric problem here is not that of setting up an acceptable probability calculus and a technique of estimation but it is the problem of what we actually find, by empirical investigation, about the form of the basic probability distribution involved and how the fisherman uses his probabilistic information concerning the future.

A second category of error elements deals with behavior itself. Probability calculus is based, at least in part, on the assumption of systematic and rational behavior of the fisherman (investor) in response to uncertainty. If the individual investor is the object of our observation, then his behavior can be assumed to be a random process instead of being systematic and rational. It may then be necessary to introduce random elements to explain changes in the behavior of the individual fisherman over time, as well as differences in behavior in a cross-section of simultaneously operating fishermen.

Thirdly, if we consider total new investment in the entire fishing industry, we will find that the final result is influenced by random elements from other behavioral sectors of the economy. Even in a very simple complete dynamic model, it would not take particularly unreasonable assumptions concerning stochastic elements to explain the most violent fluctuations in investment. But if, on the other hand, we do not want such explanations to be merely stochastic expressions, the real task is to look for as many constant elements as possible in investment behavior because we know very little about the actual determinants of investment.

Granted that realistic equations or relationships concerning economic activities would require a stochastic formulation, there is the question of what role an exercise in the use of exact relationships could play in the search for empirically significant relationships. We believe that the study of exact equations is a means of gaining insight into the way an economy, or a sub-sector of it, works. It is also an unsatisfactory procedure to add crude random errors to an exact equation just to have a stochastic relationship. There must be enough information about the probability distributions of such errors before they can be meaningfully added. We do not have such information about the fisheries industry; hence, we refrain from using stochastic equations such as visualized in equations 4.26.

There are also technical problems that may limit the use of simultaneous equation systems. We mentioned some of these problems earlier but the most difficult is the problem of aggregation. Firstly, we would like to arrive at annual total production, investment, income, number of people employed, etc., for the entire canoe component. This implies that we need aggregate models. It is difficult to find a single-valued function of capital, government activities, etc. In the canoe fisheries, capital comprises boats, gear, nets, and so on. These capital items can be very different functions for different levels of technology. Secondly, various capital items play different roles in the production process, and each item may be adjusted separately. This implies that we need several variables to represent capital in the production response function. When we try to aggregate such response functions for the different levels of technology, the resultant function may be quite unmanageable. Thirdly, a particularly difficult problem is the aggregation of government activities which of course is also important for non-stochastic or exact equations. It is difficult to find a formula which can convert all government activities into a single index. The problem is that some of these activities are not even quantifiable. For example, what units shall we use for the effects of research, training, and production campaigns such that we satisfy the measurement conditions of econometric explanatory variables? Lastly, we have a problem of aggregating capital item of varying durabilities. For example, how do we add nylon drawnets to natural fibre drawnets? How do we add a five-man canoe that can last seven years to a similar size canoe that can last only three years? In short, we have a problem of common denominators which must be resolved for effective use of simultaneous equations systems. Related to this is the inclusion of the fisherman's knowledge and experience as an input into the production response. This is not to imply that exact equations are free of aggregation problems but the flexibility of GSASA may minimize their effects.

We recognize that the partially stochastic nature of economic behavior is certainly not to be denied and must be considered seriously in economic investigations of policy alternatives; but we cannot, on the other hand, deny the enormous practical importance of exact equations. The first reason for our use of exact equations is to study how a certain type of economy, or its subsector, would operate under postulated conditions with respect to different policy alternatives. This procedure permits the study of the consequences of policy tools under, for example, a strictly given set of prices and an assumed known technology. Such exercise may provide criteria for selecting among policy alternatives that could be tested in the real world. Secondly, a large part of the general body of economic theory was handed down in the form of exact relationships. It is therefore educational to follow this approach in our search for better information on Nigerian fisheries. Finally, exact relationships can be a means of reaching reasonably realistic explanations of how the private and public decision processes interact to affect harvesting, processing, and marketing.

In view of the problems and the reasons discussed above, we therefore conclude that exact equations will be more appropriate for the preliminary phase of our study than the simultaneous equation systems (e.g. equation 4.26) of the Cowles Commission variety hoping that at the completion of the phase we will acquire enough information to use a simultaneous equations model.

Summary

In this chapter a conceptualized model of Nigerian fisheries was presented using diagrams and equations. We showed interactions among fisheries subsector, other agricultural subsectors, and nonagricultural sectors of the Nigerian economy. We also depicted a detailed, though not exhaustive, resource and information flows within the fisheries subsector or a component of it. More detailed discussion of the model was restricted to the coastal canoe fisheries while a mathematical modeling example was given for the harvesting process. Finally, we argued for the use of nonstochastic equations in the preliminary phase of our study. In the next chapter preliminary mathematical relationships will be presented.

CHAPTER V

PRELIMINARY MATHEMATICAL RELATIONSHIPS FOR THE CANOE FISHERIES COMPONENT

Introduction

In Chapter IV we presented a conceptual framework of Nigerian fisheries using the canoe component as an illustrative example. The diagrams are reference points that show interactions and resource, information, and biomass flows. In this chapter we will present a preliminary operational model of the canoe component which could be used for simulating the different processes discussed conceptually in the preceding chapter.

The equations here should be regarded as preliminary and subject to change as our knowledge of the fisheries sector improves. They provide a beginning for understanding the sector and a means of identifying the data needed for policy analysis.

Supply of Fish (The Harvesting Block in Figure 4.3)

The natural sources of fish are the ocean, the rivers, and the lakes. Population dynamics studies intended to provide information on the available biomass from these sources are still in the developmental stages in the sense that they are still species specific and we have no general model to aggregate the different species types. In Nigeria, the fishing technology of the canoe component is such that the fisherman is unable to reach that part of the continental shelf where fish is abundant. He is therefore limited, at least as of now, by his technology rather than by the availability of biomass. We may, therefore, assume an infinite supply potential, at least until we know more about biomass availability, and start our modeling from the fisherman's supply response function (5.1a).

In view of the problems discussed in Chapter IV concerning construction of equations and of our limited knowledge of the structure of the canoe fisheries, we therefore postulate generation of fish production by using either (a) active labor force (equation 5.1) or (b) gear units (equation 5.2), or (c) boat effort (equation 5.3).

(a) fish output via active labor force

$$OPT_{ij}(t) = W_{1j}FFI_{ij}(t) + W_{2i}PFI_{ij}(t) + W_{3i}FFC_{ij}(t) + W_{4i}PFC_{ij}(t) \quad 5.1a$$

$$POPN_{ij}(t) = (1 + DT*ALPHA1 - DT*ALPHA2)*POPN_{ij}(t-DT) \quad 5.1b$$

$$FTPI_i(t) = ALPHA3*POPN_i(t) \tag{5.1c}$$

$$FTPC_i(t) = ALPHA4*POPN_i(t) \tag{5.1d}$$

$$FFI_i(t) = ALPHA5*FTPI_i(t) \tag{5.1e}$$

$$PFI_i(t) = (1 - ALPHA5)*FTPI_i(t) \tag{5.1f}$$

$$FFC_i(t) = ALPHA6*FTPC_i(t) \tag{5.1g}$$

$$PFC_i(t) = (1 - ALPHA6)*FTPC_i(t) \tag{5.1h}$$

where

OPT = total fish output--tons per year

FFI = number of full-time fishermen operating in the inland waters--men

PFI = number of part-time fishermen operating in the inland waters--men

FFC = number of full-time fishermen operating in the coastal waters--men

PFC = number of part-time fishermen operating in the coastal waters--men

POPN = total population dependent on fishing for their livelihood--number

FTPI = population of fishermen in the inland water area--men

FTPC = population of fishermen in the coastal areas--men

ALPHA 1 = rate of growth of fishing dependent population (national) . . . percent per year

ALPHA 2 = rate of migration from fishing area to other areas . . . percent per year

ALPHA 3 = proportion of population that are inland fishermen--proportion

ALPHA 4 = proportion of population that are coastal fishermen--proportion

ALPHA 5 = proportion of inland fishermen that are full time--proportion

ALPHA 6 = proportion of coastal fishermen that are full time--proportion

W_1, W_2, W_3, W_4 are production per fisherman for the different groups--tons per fisherman-year (equation 5.1k)

i = indexes state

j = indexes administrative division

We assume that the level of technology of a fishing unit will be reflected in the unit's production per fisherman. In essence it is expected that a one-man fishing unit will have a small boat and simple gear and nets. He will most likely use hook and line and traps. His productivity will be small relative to the productivity of a man from a five-man team operating in the coastal waters. The problem that we may face here is in the estimation of $\vec{W} = [W_1, W_2, W_3, W_4]$. If we rely on trend data (assuming we have such data), $\vec{W}$ will only give us historical information and to use it in any projection implicitly assumes that the level of technology that produced it (i.e., $\vec{W}$) will remain unchanged. This is not consistent with the dynamic nature of the system. We must then compute $\vec{W}$ endogenously as:

$$W_{gk}(t) = W_{gk}(t_k)*[1+K*(1-e^{-\delta(t-t_k)})] \quad \forall\ t_k \leq t \qquad 5.1i$$

$$W_{gk}(t) = W_{gk}(0) \quad \forall\ t_k > t \qquad 5.1j$$

$$W_g = \sum_k a_{gk} W_{gk} \qquad 5.1k$$

a_{gk} = proportion of fishermen in the gth group of the kth technology (a will be determined in the decision process)

t_k = time at which kth technology is adopted

δ and K are constants

t = denotes current time period

g = denotes groups and k = denotes level of technology

An alternative to generating production using equations 5.1 is the gear unit approach which is given as follows:

$$OPT_i(t) = \sum_{j=1}^{J} CPU_{ij}(t)*U_{ij}(t) \tag{5.2a}$$

$$CPU_{ij}(t) = CPU_{ij}(t-DT)*[1+DT*LAMDA_{ij}(t)] \tag{5.2b}$$

where

CPU = catch per unit of gear--tons per year-unit

U = number of units of gear--gear units

LAMDA = proportional rate of growth of CPU due to experience, changes in technology, and the fishermen's responsiveness to the changes--proportion/year

i = indexes state

j = indexes gear category such as bonga nets, sawa nets, etc.

In this approach we assume that for a particular gear unit there is a fixed amount of labor required and that the efficiency of labor and machinery is reflected in CPU. Further the fisherman's response to government activities for improving the fisheries sector is implied in LAMDA which is determined by fisherman's decision process.

A final approach which we will consider is the generation of output using boat effort (BE) for each category of boat. We can identify four (4) categories of boats. Those capable of (a) operating only in the inland waters; (b) going to sea but only within the ten-fathom line; (c) operating between the ten- and twenty-fathom lines, and (d) going beyond the twenty-fathom line (large boats). Each boat category requires different types of gear and nets and a different size of fishing team. Category (a) is the least advanced technologically, while category (d) is the most advanced. For each category we will define boat-effort (BE) as the number of days that boats go out fishing in a given period, e.g., a year. The units of BE will therefore be boat-days per year. Catch per boat-day (CPBE) will depend on the size of the boat, gear and nets, depth of the fishing grounds, density of fish at fishing grounds, and on the number of men required per boat unit. Actual boat effort will depend on prices received by fishermen (or owner of the unit), and the cost incurred per boat effort for any time period.

As the price received by fishermen (PPF) goes up, more boat-efforts will be used to increase production and, hence, fisherman's income, assuming that marginal cost of a boat-effort is less than or equal to marginal return per boat-effort. On the other hand as PPF goes down, boat-effort will be reduced and, hence, production will go down. Both of the above statements assume CPBE constant for any given time period. Equations 5.3 summarize the generation of production using boat-effort.

$$OPT_i(t) = \sum_{\ell=1}^{L} CPBE_\ell(t)*BE_{i\ell}(t) \qquad 5.3a$$

$$BE_{i\ell}(t) = BN_{i\ell}(t)*BDN_{i\ell}(t) \qquad 5.3b$$

$$BN_{i\ell}(t) = BN_{i\ell}(t-DT)*(1+\eta_{i\ell}) \qquad 5.3c$$

$$CPBE_\ell(t) = CPBE_\ell(t-DT)\ (1+DELTA(t)*DT) \qquad 5.3d$$

$$BDN_{i\ell}(t) = BDN_{i\ell}(t-DT)\ (1+PED*E\Delta PPF) \qquad 5.3e$$

$$E\Delta PPF(t) = \frac{[PPF(t-DT) - PPF(t-2DT)]}{PPF(t-2DT)} \qquad 5.3f$$

where

OPT = total output (production)--tons per year

CPBE = catch per boat effort--tons/boat-day

BE = boat-effort--boat-days per year

BN = number of boats--boats

BDN = number of boat days--days per year

η = proportional rate of increase/decrease in number of boats in a category, determined by the decision process--dimensionless

DELTA = proportional rate of growth of CPBE, determined by the decision process--proportion/year

EΔPPF = fisherman's expectation of proportional rate of change of price received by fisherman (PPF) based on his experience--proportion

PED = price elasticity of boat days

ℓ = indexes boat category

i = indexes state

t = indexes time period

If we knew initial values of CPBE, PED, EΔPPF, and since we could compute BE (5.3b) then we can compute OPT using equations 5.3.

Demand for Fish

Demand for fish will be exogenous information for the fishermen. As demand for fish (Q^d) increases, the price of fish received by the fishermen (PPF) will increase. The rate of increase in the demand will depend on the proportional rates of growth of national income (gross domestic product is used as a proxy for national income here), population, and retail prices of fish and meat. Meat is used as a competing product, i.e. a substitute for fish as a source of protein. Equations 5.4 describe the demand function of fish.

$$DEMF(t) = DEMF(t-DT)*[1 + b_1 g(t) + b_2 \eta(t) + b_3 p_m(t) - b_4 p_r(t)] \tag{5.4a}$$

$$g(t) = \frac{GDP(t) - GDP(t-DT)}{GDP(t-DT)} \tag{5.4b}$$

$$\eta(t) = \frac{N(t) - N(t-DT)}{N(t-DT)} \tag{5.4c}$$

$$p_m(t) = \frac{PM(t) - PM(t-DT)}{PM(t-DT)} \tag{5.4d}$$

$$p_r(t) = \frac{PRF(t) - PRF(t-DT)}{PRF(t-DT)} \tag{5.4e}$$

where

DEMF = total demand for fish--tons per year

g = proportional rate of growth of GDP--dimensionless

η = proportional rate of growth of population--dimensionless

p_m = proportional rate of growth of retail price of meat--dimensionless

p_r = proportional rate of growth of retail price of fish--dimensionless

N = total population of Nigeria--number

GDP = gross domestic product--₦ per year

PM = retail price of meat--₦ per ton

PRF = retail price of fish--₦ per ton

b_1, b_2, b_3, and b_4 are constants

We can compute total fish output (TOPT) for the canoe component from equations 5.1, 5.2, or 5.3 as the sum of the fish outputs from each of the five maritime states.

$$TOPT(t) = \sum_i \sum_j OPT_{ij}(t) \text{ from 5.1a}$$

or

$$TOPT(t) = \sum_i OPT_i(t) \text{ from 5.2a or 5.3a} \qquad 5.5$$

This gives us the output from the harvesting of Figure 4.3. The amount of this output that reaches the next block--the processing block--is:

PRIN(t) = TOPT(t) - FVSU(t) 5.6a

FVSU(t) = BETA1*POPL(t) 5.6b

where

POPL = number of people in the locality--number

PRIN = input of fish into processing process--tons/year

FVSU = fishing village sales of unprocessed fish (this includes the quantity of unprocessed fish consumed by fisherman's family)--tons per year

BETA1 = local per capita consumption of unprocessed fish--tons per caput-year assumed constant until we know more about it.

Output from Processing and Distribution

Smoke-drying is the most widely used method of preservation of fish in Nigeria. Storage facilities are virtually unavailable and before processing is completed there is a substantial amount of fish lost. Output from processing can therefore be described as

PROPT(t) = (1 - BETA2)*(1 - BETA3)*PRIN(t-DT) 5.7*

*The actual form this equation will take will be determined when we have more information about the process. At this point we do not know whether a distributed delay (Chap. III) or this discrete one DT delay (equation 5.7) will be appropriate. Until then equation 5.7 should be viewed as a hypothesis.

where

PROPT = processed output--tons/year

BETA2 = proportion of PRIN lost due to drying--dimensionless

BETA3 = proportion of PRIN lost due to wastage in the process--dimensionless

The input into the distribution process is:

$$DISTIN(t) = PROPT(t) - FVSP(t) \qquad 5.8a$$

$$FVSP(t) = BETA4*POPL(t) \qquad 5.8b$$

where

DISTIN = input into the distribution process--tons/year

FVSP = fishing village sales of processed fish including the amount set aside by processor for domestic use--tons/year

BETA4 = local per capita consumption of processed fish--tons per caput-year

The output of fish that reaches the terminal (distant) market can be computed as the amount of fish which reaches the distribution process less the quantity wasted during transportation either as a result of bad handling, lack of storage, bad packaging, or a combination of these. This output is

DISOPT(t) = DISTIN(t) - DISW(t) 5.9a

DISW(t) = BETA5*DISTIN(t) 5.9b

where

DISOPT = output from distribution process--tons/year

DISW = distribution wastage--tons/year

BETA5 = proportion of processed fish lost due to distribution wastage--dimensionless

Income Generation

If we assume that the fisherman is both the processor and retailer of his product, then we can compute the gross income to the canoe fisheries component as described by equations 5.10.

CFGY(t) = PPFU(t)*FVSU(t) + PPFP(t)*FVSP(t)

+ PRF(t)*DISOPT(t) 5.10a

CFNY(t) = CFGY(t) - CFTC(t) 5.10b

CFTC(t) = FC(t) + CC(t) + PC(t) + TRC(t) 5.10c

$$FC(t) = \sum_k [(\frac{TCB}{ECLB} * BN)_k(t) + (\frac{TCG}{ECLG} * U)_k(t)] \quad 5.10d$$

$$CC(t) = [FW(t)*PLH(t)*RIP(t) + (1-PLH)*RIP(t)$$

$$*PA(t) + PBC*XBC(t)]*FINN(t) \quad 5.10e$$

$$PC(t) = PFW(t)*QFW(t) + FW(t)*ALIP(t) \quad 5.10f$$

where

CFGY = canoe fisheries gross income (this is value of all produce)--₦/year

CFNY = canoe fisheries net income--₦/year

CFTC = canoe fisheries total cost--₦/year

PPFU = price of unprocessed fish--₦/ton

PPFP = price of processed fish (sold locally)--₦/ton

PRF = retail price of processed fish--₦/ton

FVSU = as defined in equation 5.7

FVSP = as defined in equation 5.8

DISOPT = as defined in equation 5.10

FC = fixed cost, i.e., cost of establishment--₦/year

CC = cost of catching (e.g., labor and cost of other variable inputs)--₦/year

PC = cost of processing--₦/year

TRC = transportation cost--₦/year

TCB = initial cost of boat--₦/boat

TCG = initial cost of gear and other equipments--₦/gear

ECLB = economic life of boat--years

ECLG = economic life of gear and nets--years

BN = number of boats in each category--boats

U = number of gear units--gear units

FINN = number of fishermen in the component

j = indexes category or technological level

FW, PLH, PA, PBC, RIP, and XBC as defined in 5.14

PFW = price of firewood or fuel used--₦/lb.

QFW = quantity of firewood or fuel used--lbs./year

ALIP = amount of labor input used for processing per year--man-hrs./year

The gross and net incomes computed as in equations 5.10 are performance variables which can help the public sector (i.e., the government) evaluate the effectiveness of programs and policies designed to improve the income of the canoe component. The same set of equations can be used, with some modifications, to evaluate the income distribution within the fisheries.

Equation 5.10a aggregates income in fisheries vertically; actually, the fisherman is only a retailer in his local (the fishing village) market. He is, as at present, a processor but he sells his processed fish to a middleman who sells it to retailers in urban markets. In order to see the income distribution within the component clearly, we have to compute the fisherman's gross and net incomes and the middleman's and retailer's incomes separately. Equations 5.11 compute these.

$$FGY(t) = PPFU(t)*FVSU(t) + PPFPL(t)*FVSP(t) + CFM(t) \qquad 5.11a$$

$$FNY(t) = FGY(t) - FTC(t) \qquad 5.11b$$

$$FTC(t) = FC(t) + CC(t) + PC(t) \qquad 5.11c$$

$$GYM(t) = PRFM(t)*[DISTIN(t) - DISWM(t)] \qquad 5.11d$$

$$TCM(t) = CFM(t) + TRC(t) + TCMM(t) \qquad 5.11e$$

$$CFM(t) = PPFPM(t)*DISTIN(t) \qquad 5.11f$$

$$YNM(t) = GYM(t) - TCM(t) \qquad 5.11g$$

$$DISW(t) = DISWR(t) + DISWM(t) \qquad 5.11h$$

$$RGY(t) = PRF(t)*[DISTIN(t) - DISW(t)] \qquad 5.11i$$

$$RTC(t) = RFC(t) + RCF(t) + RCM(t) \qquad 5.11j$$

$$RNY(t) = RGY(t) - RTC(t) \qquad 5.11k$$

$$RCF(t) = PRFM(t)\ [DISTIN(t) - DISWM(t)] \qquad 5.11\ell$$

where

FGY = fishermen's gross income--₦/year

FNY = fishermen's net income--₦/year

FTC = fishermen's total cost--₦/year

FC, CC, PC = as defined in equation 5.10

PPFU, FVSU, FVSP = as defined in equation 5.10

DISTIN = as defined in equation 5.8

PPFPL = price of processed fish at the local market--₦/ton

PPFPM = price of processed fish received by the fisherman from the middleman--₦/ton

GYM = middlemen's gross income--₦/year

TCM = middlemen's total cost--₦/year

YNM = middlemen's net income--₦/year

PRFM = price of processed fish received by the middleman--₦/ton

DISWM = fish wastage incurred by middleman--tons/year

TRC = as defined in equation 5.10

TCMM = middleman's handling cost (includes his labor)--₦/year

RGY = retailers' (market woman) gross income--₦/year

RTC = retailers' total cost--₦/year

RNY = retailers' net income--₦/year

CFM = cost of fish to middlemen (i.e., what is paid to fishermen--processors)--₦/year

RCF = cost of fish to retailers (i.e., what is paid to middlemen)--₦/year

RCM = retailers' management costs--₦/year

RFC = retailers' fixed costs--₦/year

DISWR = wastage incurred by retailers--tons/year

A comparison of FNY, YNM, and RNY will show if there is a disproportionate share of the consumer's naira going to one of the three sections--primary producer-processor, middleman, and retailer. If there is, the information will help in the formulation of appropriate policies to correct the inequity.

Price Generation

$$FW(t) = FW(t-DT) + DT*FWR \qquad 5.12a$$

$$PXE_h(t) = \sum_{q=1}^{Q} PFEN_{hq}*\{(DR_q(t)*PK_q)/[1 - \exp(-DR_q(t)$$

$$*ECL_q)]\} \qquad 5.12b$$

$$EPPF_h(t) = EPPF_h(t-DT) + E\Delta PPF(t)*EPPF_h(t-DT) \qquad 5.12c$$

where

FW = as defined in equation 5.17

FWR = rate of growth of FW--₦/man-hr-year

DR, PXE = as defined above

EPPF = producer-processor price expected by fisherman--₦/ton

EΔPPF = as defined in equation 5.3

PK = initial price of the qth equipment (e.g., boat, engine, gear, etc.)--₦/unit

ECL = economic life of the equipment--years

PFEN = number of equipments per fisherman--equipment units/fisherman-year

exp = exponential function

q = indexes the equipment types (q = 1, 2, Q)

Investment Generation

The model will compute fishermen's investment in all categories (i.e. fisheries investment) as given in equations 5.13. Investment by a fisherman is of two types. He may invest in fisheries or in nonfishing activities. Similarly, there are two types of investment into fisheries. The first is the investment in fishing by fishermen or other participants in the industry, while the other is investment in fishing from outside the industry.

FIN(t+DT) = FYAI(t) + CAFU(t) + OITF(t) 5.13a

FYAI(t) = (1-GAMMA(t))*(FNYT(t)+FNYO(t)) 5.13b

GAMMA(t) = ALPHA + B(t) 5.13c

OIFF(t) = B(t)[FNYT+FNYO] 5.13d

where

FIN = fisheries investment--₦/year

FYAI = fishermen's income available for investment--₦/year

CAFU = credit available and used for investment in fisheries--₦/year

ALPHA = proportion of income required for fishermen's consumption, assumed constant over time--proportion

B = proportion of income invested by fisherman outside of fishing, a function of time determined by the decision process--proportion/dimensionless

FNYT = fishermen's net income from fishing--₦/year

FNYO = fishermen's net income from nonfishing activities--₦/year

OITF = outside investment into fishing--₦/year

OIFF = fishermen's investment in nonfishing activities--₦/year

Total investment in fishing depends on the proportion of total income available for investment and the amount of credit and/or loan that is available to participants in the fishing industry. The amount of income available for investment (FYAI: equation 5.13b) is dependent on net income from all fishermen's economic activities, both fishing (FNYT) and nonfishing (FNYO), on the fishermen's propensity to consume (ALPHA), and on the "attractiveness" of outside investment (B(t)). Outsider's investment in fishing (OITF) is a function of profitability of fishing, government policies (e.g., special credit terms that apply only to investment in fishing, tax incentives, and input subsidies), and income. Because of the limited information on the fishing industry and its interactions with other sectors of the economy we cannot postulate the structure of OITF explicitly. The same is true of the investment in nonfishing activities from the fishing industry. Though we know that such investment must depend on the income from fishing and nonfishing activities, it also depends on B which varies with time. Consequently, OITF is treated exogenously but as a function of time in the model and B will be determined by the decision process.

If the fisheries investment, FIN, as computed above is less than total capital required for transition from fishermen's present use of resources to a new use, then constraints will be imposed on consumption and investment. Equations 5.14 are used to compute these constraints. The fishermen's demand for net investment will be determined by the decision process.

$$COI_{\ell}(t+DT) = COI_{\ell}(t) + \frac{DT}{DTX} * [CCOI_{\ell}(t) - COI_{\ell}(t)] \qquad 5.14a$$

$$CCOI(t+DT) = \min[\frac{CAFU(t) + FYAI(t)}{FDNI(t)}, 1] \qquad 5.14b$$

where

COI = averaged investment constraint--dimensionless

CCOI = consumption constraints on fishing investment--dimensionless

DTX = the decision cycle--years

ℓ = indexes the boat category

FDNI = fishermen's demand for net investment--₦/year

Private Resource Allocation Decision Process[1]

In this subsector investment decisions are made by the individual fisherman or fishing unit. Even when there is a team of fishermen there is a leader or manager whose responsibility it is to make decisions and to bear

[1]This section adapts equations from Chapters III, IV, and V of [1].

the risk involved in such decisions. In this section we will call such a manager the fisherman, the private decision maker.

Allocation of resources for either consumption and/or production over time is an economic decision, and it is the main concern of investment theory. Demand for investment goods is a derived demand, derived from the demand for the final product for which the investment is undertaken. The fisherman's decision to invest in larger boats, outboard engines, improved gear, and nets is based on his expectation of profits that he will make on the sale of fish (final product) which he will catch with his equipment. However, many problems confront the decision maker when he has to choose among productive investment opportunities. For the fisherman the choice is for his own good or well-being, but in the public decision process the choice is on behalf of other people, institutions, or society for whom the decision maker is empowered to act. The greatest problem facing him is the incompleteness or "imperfectness" of knowledge about the true costs--costs of inputs, social costs, opportunity costs, etc.--and about the benefits that are attached to each of the alternative actions open to him. A further problem he faces is that some of the social costs and benefits are not reducible to money terms. Even if he knew the full consequences of each course of action and could express the costs and benefits of each in money terms or other quantifiable measures, his decision rule must be flexible enough to allow for adjustments should his expectations change as time passes.

He is assumed to act as if decisions were based on a formula which we call "relative profitability differential" (equation 5.15). This is computed by taking the difference between the discounted sum of net returns from a new and present alternative uses of his resources over a planning horizon. He then expresses the difference as a ratio of his present net returns. The ratios are compared for several new alternative uses and the best alternative is chosen.

Resource use decisions depend not only on the relative profitability of each alternative but also on modernization promotion efforts, on the availability of boats, gear and nets, and other inputs, on the availability of capital and credit and the ease of access to them, on diffusion effects, and on the behavioral characteristics of the fisherman making the decisions. The fisherman's decisions on choice among the alternative uses of his capital, labor, and other resources are not based on the actual relative profitabilities, which may not be known because of uncertainty, but on his perception of them. The fisherman's perception of relative profitability of an alternative m to his present use p of resources is given by equation 5.15.

$$RPF_{mp}(t) = \frac{DSUM_m(t) - DSUM_p(t)}{|DSUM_p(t)|}, \quad m = 1, 2, M;$$

$$p = 1, 2, \ldots, P; \qquad 5.15$$

where

RPF = the relative profitability differential--dimensionless

DSUM = discounted sum of net returns over the planning horizon--₦/fisherman (if alternative "a" is used, it will be different for b and c)

m = indexes the alternative to the present use $m = 1, 2, \ldots, M$

M = number of alternatives open to a present use--number

p = indexes the present uses of resources $p = 1, 2, \ldots P$

P = number of present uses--number

The profitability of a resource use is perceived by the fisherman as the present value of the stream of net income which he expects to receive over some planning horizon. Planning horizon is used here because fishing cannot be treated on an annual basis alone. Fishing requires acquisition of input units such as boats, gear and nets, and engines. These are durable goods with each having an economic life and cost extending beyond one year. The economic returns from each must cover the cost and must have enough left over for payment to management for its entrepreneurship and risk bearing. The cost is therefore amortized over a period of time which is referred to here as the planning horizon.

The model will compute DSUM of a resource use from the present up to the planning horizon. This is given in equation 5.16.

$$DSUM(t) = \sum_{h=1}^{H} \frac{[TR_h(t) - TC_h(t)]}{[1 + DR]^h} \qquad 5.16$$

where

DSUM = as defined above

TR = total revenue--₦/fisherman-year

TC = total cost--₦/fisherman-year

DR = relevant discount rate--proportion/year

h = indexes H years of planning horizon

H = meaningful planning horizon--years

DR, the discount rate, is a behavioral parameter. It is the fisherman's judgment of how risky an alternative is as evaluated by him. There is a different discount rate for a different alternative; the relative difference reflects his varying attitude towards adoption of an alternative use of his resources, particularly the modern alternatives such as investing in outboard or inboard engines. The more risky and the more unfamiliar the alternative the higher the DR implied in his decision. For example, if there is a fisherman who is presently operating a small boat but wants to choose between buying a larger boat without an outboard engine and buying one with an outboard engine, he will set the DR for the boat with an engine higher than the DR for that without an engine in computing DSUM because a boat with an engine represents a higher investment and an unfamiliar technology since he has not operated an engine-propelled boat before.

Since the decision-making process of the fisherman is partly based on his expectations of the future, the streams of future revenues and costs used in profitability calculations should reflect these expectations. Thus, the producer-processor price used must be what he expects to receive for his product. Equations 5.17a and 5.17b compute revenues and costs respectively. Prices are computed in equations 5.12.

The cost side includes, as technological coefficients, biological, labor, and capital (gear, nets, engines, and other equipment) input requirements over the planning period. Associated input prices are treated as exogenous. The imputed wage rate increases linearly with time.

This preliminary model treats opportunity cost as an exogenous variable and restricts it to the opportunity cost of labor. Realistically, opportunity cost should be viewed in terms of marginal value product of the different inputs, both within the fishing enterprises (analogous to on-farm opportunity cost) and outside fishing (off-farm opportunity equivalent). Thus, PA should be determined endogenously. This limitation could be removed when adequate data are obtained to construct an explicit production function from which marginal value products could be computed. Meanwhile, we will assume that the fisherman's assets, except his unskilled labor, are fixed in such a way that the salvage value of his fishing assets are zero outside fishing, but positive within fishing and that their (assets') marginal value products are less than the acquisition values of their replacements. Thus, there is a need for government subsidy to either reduce acquisition values of new inputs or increase marginal returns to the fisherman if production is to be expanded.

$$TR_h(t) = EPPF_h(t)*OPTP_h(t) + FSG_h(t) \tag{5.17a}$$

$$TC_h(t) = FW(t)*RIP_h(t)*PLH(t) + PBC*XBC_h(t) + PXE_h(t) + PC_h(t) + PA(t)*RIP_h(t)*(1-PLH(t)) \tag{5.17b}$$

$$OPTP_h(t) = BEPF_h(t)*CPBE(t) \tag{5.17c}$$

where

TR = fisherman's total revenue--₦/fisherman-year

TC = fisherman's total cost--₦/fisherman-year

EPPF = producer price expected by fisherman--₦/ton

OPTP = fisherman's output--tons/fisherman-year

FSG = subsidy or grant received by fisherman from state and/or federal government--₦/fisherman-year

FW = wage rate paid in fisheries--₦/man-hr

RIP = labor input requirements--man hours/fisherman-year

PLH = proportion of hired labor--proportion

PBC = composite price for other inputs (e.g., petrol)--₦/unit

XBC = quantity of the other inputs--units/fisherman-year

PXE = price of equipment service--₦/fisherman-year

PC = processing costs (wood, oil, labor, etc.)--₦/fisherman-year

PA = opportunity cost of labor (e.g., government or industrial wage rate)--₦/man-hour

BEPF = boat effort per fisherman--boat-days/fisherman-year

CPBE = as defined in equation 5.3--tons/boat-day

h = indexes the H years of the planning horizon (h = 1, 2, . . ., H)

Public Resource Allocation Decision Process

The fisherman's response to the relative profitability cannot be considered in isolation from the public decision process. The fisherman makes use of information on variables such as government subsidies or tax incentives on petrol, on training facilities to acquaint himself with new ways of using new inputs, on loan and credit programs of both government and private institutions, on costs of inputs, on available biomass and on prices. These pieces of information reach the fisherman partly through extension agents. The public decision process block also uses the information in order to consider various possible alternative means of disseminating information and of promoting production increases. Since the government, acting for the public sector, uses extension agents for spreading information, we expect the agents to be the main form of promotional and/or educational information units (extension agent equivalents).

Information units (extension agent equivalents), part of which come out of the "extension" block of Figure 4.3, can be computed as in equation 5.18a. It is made up of two parts: namely, promotion information units from the extension block (EINF) and demonstration effect information units which are actually diffusion information. The diffusion information represents the effect of interaction among the fishermen. This is the effect of fishermen learning new techniques or alternative use of existing techniques from one another. This is therefore endogenously determined. EINF is dependent on the governments that provide extension agents to promote what, in their view, is adequate for promotional purposes. EINF is therefore treated exogenously in the model.

$$TINF_{mp}(t) = EINF_{mp}(t) + DINF_{mp}(t) \qquad 5.18a$$

$$DINF_{mp}(t) = \frac{TBAVD_{mp}(t)*TBALT_m(t)*CIUD_{mp}}{TBAVD_{mp}(t) + TBALT_m(t)} \qquad 5.18b$$

$$TBAVD_{mp}(t) = TBPT_p(t)*PBPT_{mp}(t) \qquad 5.18c$$

where

TINF = total information units--extension agent equivalents (eae)

DINF = diffusion information units--eae

EINF = promotional information units--eae

TBAVD = number of boat units (when alternative c is used) in a present use suitable for alternative use by diffusion--boat units

TBALT = number of boat units in the alternative use--boat units

CIUD = a coefficient reflecting the information effect of demonstration boat units--eae/boat unit

TBPT = total number of boat units that can be converted to an alternative use--boat units

PBPT = proportion of boat units in a present use that can be converted into a particular alternative--proportion/dimensionless

m = indexes the alternative

p = indexes the present use

This information will enable the government to plan the transition of the canoe component from its present low productivity per fisherman to high productivity by its investment in EINF. In order for the transition to be successful, we must model the fisherman's transition response.

Changes in the patterns of use of boats, gear and nets, and other resource inputs reflect a fisherman's responses to the perceived profitabilities of the fishing alternatives available to him. The most profitable alternative will likely be the first choice of most fishermen as decision makers, and the other alternatives will follow in a descending order of profitability. Profitability response will be computed in the model as

$$PR_{mp}(t) = \max\{AMP_{mp} * (1 - \exp[-RPR_{mp} * (RPD_{mp}(t) - PRTH_{mp})]),\ 0.\} \qquad 5.19a$$

$$AMP_{mp} = \min\left\{\frac{TBAVP_{mp}(t)}{TINF_{mp}(t) * CEFF * DT},\ 1.\right\} \qquad 5.19b$$

where

PR = the profitability response to promotion effort--proportion

AMP = maximum proportion attainable

exp = exponential function

max = a function that takes the maximum of the terms within the brackets

RPR = the rate of promotion response with respect to profitability--dimensionless

PRTH = the promotion response action threshold--dimensionless

RPD = as defined in equation 5.15

TBAVP = number of boat units in present use available for a particular alternative by promotion--boat units

EINF = promotion information units (extension agent equivalents)--eae

CEFF = potential efficiency of promotion--boat units/eae-year

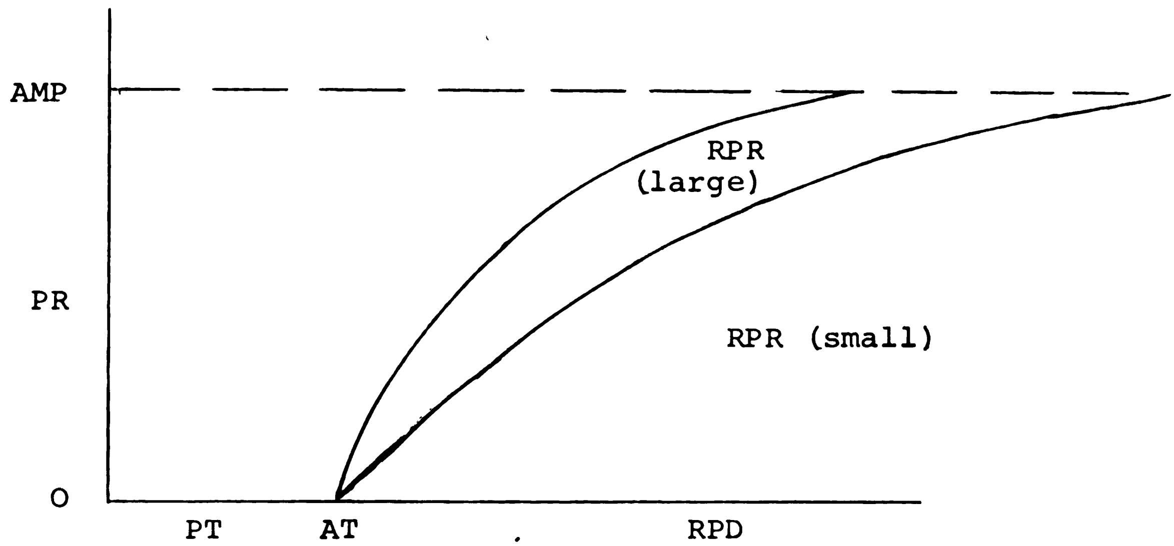
m = indexes the alternatives

p = indexes the present uses

Promotion campaigns are not restricted to the public sector. Private firms that produce boats, nets, gear, etc. can embark on promotion campaigns to sell their products which, being inputs to the fishing firms activities, can generate responses from the fishermen.

The profitability response function, equation 5.17a, determines what proportion of boat units in a given category an extension agent (an information unit) can convert from one use to another in a given time period. Such a conversion could be from nonmotorization to motorization of boats or fishing in the inland waters to fishing in the coastal waters. The calculation of PR is dependent on the profitability of the alternative, on the efficiency of the information unit, on the boat units available for transition and on the behavioral characteristics of the fisherman.

The efficiency of an extension agent is the maximum number of boat units he is able to convert in a year as the profitability of the alternative grows. Equation 5.19a computes the proportion of that efficiency which can be attained for a given profitability level. The maximum attainable proportion is 1.0; however, if there is a boat unit constraint--e.g., lack of supply of necessary gear for an alternative use of boat units--relative to the number of extension agents and their efficiency, the maximum attainable proportion will be less than the potential efficiency.



PT = Perception threshold

AT = Action threshold

Figure 5.1: Response to an (m, p) Pair

The threshold and response rate parameters shown in Figure 5.1 reflect the fisherman's attitudes and behavioral characteristics which affect the rate of his response to the relative probabilities of various alternatives (M) facing him. The factors represented by both of these parameters include, for instance, the degree to which the fisherman's assets are fixed, opportunity costs of alternative uses in terms of the present use, risk aversion, and fisherman's attitudes towards government programs and politicians' promises.

Figure 5.1 represents one of the (m, p) pairs to which the fisherman reacts. He is perceived as having two types of thresholds. The first is his perception threshold (PT) which is the point at which his interest is ignited by the prospects of profits in an alternative (m) to the present (p) use of his resources. For every present use, p, there may be several alternative uses ($m > 1$ for a given p) but there is only one PT for an (m, p) pair. The relative profitability differential is, however, too low for him to take action and, hence, his response (PR) is zero at PT. If, at this point, the extension agents' efforts at promotion are relaxed because of the enthusiastic participation of fishermen in meetings, for example, there will be no response because the fisherman is still in the learning situation. RPD at this point, PT, is not good enough to induce response; to the fisherman the risk of adoption or response is still too high to take. If the promotion efforts are continued and intensified, he (fisherman) may reach his second threshold--the action threshold (AT) where RPD is high enough to induce a response (his $PR > 0$). As information (TINF) increases with time, AT will approach PT and this will affect the fisherman's decision on DR. Because he is more informed and experienced he will perceive less risk in adopting new technology and be willing to reduce the DR associated with new alternatives. Conceptually, we can consider DR, the discount rate, as varying inversely with TINF over time until DR is such that AT-PT = 0 i.e. AT = PT. This could be the situation which Johnson and Lard (38) described as risk situation. There are other factors that can lead the fisherman to this situation or that can affect his decision. For instance, the government and/or private banks can reduce the cost of capital to the fisherman by making loans available to him at low interest rates in order to make the use of new techniques more profitable than the use of existing ones; prices of fish may increase because of increases in effective demand for fish; out-migration can reduce the number of fishing units and thus reduce competition for fish harvesting; and government may give subsidies either in cash or through subsidized inputs. All these will affect RPD (actually increase it) and, hence, fisherman's decision. As long as RPD is greater than or equal to AT the fisherman's PR will be positive i.e. PR > 0.

Many programs and projects in LDC's have failed probably because the promoters failed to bring the projects to the adoption-action-threshold, i.e., AT. The profitability level (RPD) which will induce action or response from fisherman is at the point where RPD = AT; beyond this point the higher the RPD the higher the response (PR). The magnitude of RPR, the rate of profitability response for an (m, p) pair, determines how fast profitability response (PR) approaches its potential, AMP. If RPR is small, PR will take a longer time and higher RPD to reach AMP as shown by RPR (small) in Figure 5.1.

When the RPD reaches AT the fisherman responds with an increased rate of utilization of his existing inputs and/or invests more capital in expanding his fishing units. These are examples of two (m, p) pairs: for this p there are two alternatives (M = 2), namely, increased rate of utilization of existing fishing units and investment of more capital to expand fishing units. In the former case, the price of service of equipment (equation 5.12b) will go up and, hence, his total cost (equation 5.17b) may go up. This alternative may not be as profitable as investing more capital. However, his investment will depend on his income, on credit available to him, and on his consumption requirements.

The difficulty encountered in separating the public and private decision processes is evident because this section could as well be called "private decision process." It, however, emphasizes the flow of information between the two and, hence, interaction between the private and the public sectors. The discussion further showed that decision making is an iterative process as depicted by the different thresholds which the fisherman goes through. The government must therefore evaluate its programs as it obtains information on the fisherman's response (PR) to various projects, programs, and policies. This iterative process is one of the main points of GSASA which has a built-in feed-back control in its policy analysis.

As our knowledge situation in Nigerian fisheries, particularly in the canoe component, improves, we may find it necessary to add to, subtract from, and/or modify the equations presented herein. For example, when we say "boat unit" or fishing unit, we mean the boat, the gear and nets, and the manpower requirements that make the unit a productive unit. In equations 5.13 and 5.14 we did not separate the boats from the gear. However, if we need to consider the acquisition of gear and nets separate from, or independent of, boats or of boat efforts, we can model gear and nets separately. If the gear units required by the available boats is greater than the supply of gear units, then there is excess demand for gear units and fish production will be constrained by the insufficient supply of gear units. Without outside interference price of gear will go up and cost of production will go up correspondingly. This process will continue until, for example, either the rising prices of gear increases gear supply to such a level that forces prices down or enough fishing units are shut down and the demand for gear units goes down thus forcing prices down.

Another aspect that can be modeled is the labor requirement. If labor required by available boat effort is greater than labor supply there will be a shortage of labor and this will impose a constraint on production. If, on the other hand, there is excess labor supply there will be unemployment in the fishing canoe component unless labor services can be bought from, or sold to the nonfishing sectors of the economy.

In this chapter an operational model has been presented. The application of the model is, however, dependent on the availability of relevant data. The type of data which is suitable for policy analysis using this model is not available and, consequently, the need for basic data in fisheries development is one of the subjects of the next chapter.

From the work done in this chapter we can conclude that mathematical relationships can be constructed to describe the Nigerian canoe fisheries component. However, elaboration of the model and its empirical verification will be delayed until necessary data are obtained in Nigeria. In the next chapter data requirements will be discussed and an operational plan for more work on this model will be presented.

CHAPTER VI

AN OPERATIONAL RESEARCH PLAN

Introduction: Need for Data

Researchers often face data problems even in the developed countries. They are, many times, forced into using unsatisfactory sources of data. The reliability of data may be questionable because of poorly designed and/or executed sampling procedures. In less developed countries (LDC's) such as Nigeria, these problems are compounded by poor data processing and poor communications when there are any data. In the fisheries subsector of the Nigerian agricultural sector, the data situation leaves much to be desired.

Fisheries, like the other subsectors of agriculture (i.e., livestock, forestry, and crops) was, until 1967, the responsibility of the then regions and there was little federal coordination in fisheries development. Consequently, little attention was paid to basic data collection for fisheries at the national level. This state of affairs may be due, in part, to the low priority accorded fisheries by the regions and later by the states.

In the 1962-68 development plan, none of the four regions spent all of the fisheries planned expenditure (43). Since the establishment of the Federal Department of Fisheries, there are other reasons which may explain lack of basic data besides lack of federal coordination. These include a shortage of well-trained, data-collecting manpower, emphasis on biological research by the department at the expense or less emphasis on collection of nonbiological data, inexperience on the part of the new states with respect to relevant data for collection, and reliance of the governments (federal and state) on ad-hoc surveys and itinerant researchers. Distrust on the part of fishermen of outsiders in general and of government in particular may have contributed to the lack of data.

Almost regardless of how unreliable the data, the approach proposed in this thesis can help solve, at least in part, data problems through the use of sensitivity tests. Sensitivity tests, apart from demonstrating the implications of parameter variability both for the validity of the model and for policy formulation, can indicate the directions that data collection efforts can most profitably take.

The data requirements for the model presented in Chapters IV and V are extensive. We have made use of the available descriptive information and theoretical concepts to build the preliminary model and to construct the functional relationships presented in Chapter V. These functional relationships will be modified, changed, taken out, and added to as our knowledge of the structure and of the functioning of the system improves. In order to operationalize the model, coefficients and parameters must be read into the computer program as data input. This data input falls into three categories. These are system parameters, technological coefficients, and initial conditions.

System parameters are parameters which reflect behavioral characteristics of the system being modeled. The parameters, along with the structural equations, actually define the system. At this stage of the fisheries model we cannot claim that we have really defined the system because of a scarcity of information on both the structure and the parameters of the system. Such parameters will include profitability response parameters (PRTH, RPR in equation 5.19) and the discount rate (DR in equation 5.16), for example.

There are no data on these parameters and the kind of field research useful in obtaining them has not been conducted. We need time-series and cross-section data for statistical estimates of the parameters. We could also use estimates from knowledgeable individuals but these are not available. The other alternative is to use secondary sources of data. These sources include FAO reports (26), CSNRD reports (12), and FOS reports (24), among others.

The CSNRD reports concentrated on the crop sub-sector of our agricultural economy with some reference to livestock as a source of protein. Nigeria's research needs as seen and as recommended by the consortium include research emphasis on soil fertility, crop production (export and food crops) with particular attention paid to food crops, livestock development, food technology (12: Nos. 8, 22). There is no mention of fisheries as a source of food and there was no recommendation for research efforts to be put on it. The FAO report (26) devoted one chapter (Chapter XV) to fisheries but the authors were not enthused about the development of fisheries. The report concluded that "Although complete information is net yet available, it is fairly certain that Nigerian fishery resources as a whole are not as abundant as in neighboring countries and that potential for their development is limited." The report went on to recommend that Nigeria should accord low priority to her fisheries, especially inshore and distant-water trawling, and Nigeria should, at the same time, encourage imports of fish. The Nigerian policy-makers relied heavily, at least until 1968, on experts' reports which did not encourage research investment on all aspects of Nigerian fisheries. This state of affairs has contributed immensely to the scarcity of data on Nigerian fisheries. The current state of data in fisheries is one of inconsistency, contradiction, and incompleteness. These secondary sources which were used for intuitive guesstimates of the southern model (47) are thus not available for fisheries.

It can be argued that some estimates, any estimates, of the behavioral parameters could be assumed initially to solve the data problem. This may be true, but we contend that such assumptions (i.e., the assumed estimates) must be based on prior knowledge of the system's behavioral characteristics. We do not possess this knowledge and any analysis based on a set of assumptions not founded on knowledge will be, for our purpose, an irrelevant exercise; hence we emphasize the need to acquire knowledge of the system.

For example, it is difficult to determine how profitable an alternative such as mechanical propulsion (as against manual propulsion) must be before a fisherman will change from manual to mechanical propulsion. It is therefore necessary to understand and obtain information on the fishermen's responsiveness to promotion and diffusion as well as profits.

In most agricultural studies, especially in crop studies, technological coefficients are easy to obtain, but this is not so for fisheries. Data on catch per boat effort (CPBE), labor input (RIP), petrol input, and input prices are presently unavailable. Research and field work will be necessary to obtain these data on the technical coefficients needed for operationalizing the model.

Initial values of variables which change over time must be reset at the start of each simulation run. Some of these variables include fish prices (PRF, PPF, etc.), processing proportions (BETA2, BETA3, and BETA4), and initial use of boats. These initial values are a prerequisite to any application of the model. The sensitivity tests of the model cannot be carried out without them. The data categories discussed below apply to each of the components even though we continue to use the canoe component as illustration.

Research Needs

We have discussed and established the need for basic research on Nigerian fisheries in the preceding chapters. In this section we will concentrate on specific data requirements, categories, collection, and processing.

Data Requirements from the Fisheries Subsector

Periodically, the Federal Office of Statistics (FOS) conducts rural economic surveys. Such surveys were conducted in 1958-59, 1963-64, and in 1969-70. Since the emphasis of the survey was on rural economic activities, it is appropriate to expect that canoe fisheries, the major activity of the coastal inhabitants of the maritime states, would be adequately covered and that primary data necessary for policy formulation, analysis, and evaluation would be available. This is not true of the resultant reports from the surveys. Emphasis for data collection was put on crops and livestock. The kinds of data collected include size of farm, crop acreages, crop yields, population data such as births, deaths, and slaughter of livestock (goats, sheep, cattle, etc.), prices of livestock, household composition (for labor availability), capital expenditures and operating expenses, equipment used, information on hired labor, sales of produce, and information on acquisition of capital stock. These data from the rural economic surveys were designed to measure and interpret changes in the rural economy in order to provide information "necessary for planning in the specific subsectors of agriculture" (24). The specific objective of the rural economic surveys was to collect data on farming and rural life in recognition of the fact that these data "are necessary prerequisites for formulating plans of economic development and in particular agricultural development and (for) evaluating progress in the implementation of such plans" (24). The extension of these surveys to the fishing rural areas would have provided information necessary for planning in the fisheries subsectors. The FOS failed to achieve its objective by leaving out the fishing villages in its sampling. At least this is implied in its reports.

The farm surveys emphasized yield, but this was limited to crop yield while FOS's consumption enquiry included fish products. There was an attempt at reporting domestic production of fish especially for Western State in the enquiry, but the data become questionable when a person notes that production of dried fish for Ondo province is zero. The Ilaje (or eastern) fishing area is located in Ondo. The highest production per fisherman, 2.2 m. tons per year, was recorded for Ilaje area (19). Finally about 70 percent of fish caught along the coast is smoke-dried. This implies that around 70 percent of fish caught in Ilaje area must have been dried. These facts contradict the FOS report on fish production as recorded in the consumption enquiry and raises a question of the reliability and the adequacy of such data for the kind of in-depth analysis necessary to provide reliable projections of the criteria variables to be used for choosing among various alternative development policies.

If we were to derive Nigeria's demand for fish in 1963-64 using FOS data (24), we would have an average of 19 kg per caput per year. With a population of 55.6 million people, the estimated consumption for 1963-64 was about 1,056,400 metric tons. Let us assume that the actual consumption was only one-half of this estimate. This gives a consumption figure of 528,200 m. tons. In the same period our import of fish was 263,000 m. tons. This implies that the excess must have come from domestic production. This would have given us a domestic production of 265,200 m. tons. However, in 1963-64, our domestic production was estimated at 58,000 m. tons. If we add chartered vessels landings of 22,000 m. tons we obtain 80,000 m. tons which falls far short of 265,200 m. tons. This is not a small margin.

All of this points to the immediate need for data collection in the fisheries subsector in order to obtain meaningful information for planning.

This was the state of data in fisheries when the fisheries report (53) was prepared for the National Agricultural seminar and when the present (1970-74) plan was drawn up. The 1975-79 development plan is only two years away and by 1974 we must have a new plan ready, but the data situation remains as it was at the end of 1965. The information needs listed below will have their first utility in meeting this short-run data requirement if work starts on it immediately. The exercise should, however, continue to provide a data bank for planning.

The list below assumes that the data will describe boat or fishing units as functional decision-making units which operate under a set or sets of economic factors--opportunity sets and constraints. It will also be assumed that the data will be useful for policy simulation of the sector with a view to studying the consequences of alternative policies over time. Data must provide information necessary for answering policy questions such as (a) what policy will be most effective in improving incomes, employment opportunities and wealth of the coastal rural people? (b) what changes are needed in the canoe fishing structure and resource mix to stimulate production? (c) is the availability of labor, capital, and inputs a limiting factor to fish production? (d) how responsive to change are the fishermen? etc. Before we discuss the list of data categories, however, we will discuss data requirements from non-fishing sectors and present an operational plan for our proposed research project.

Data Requirements from Nonfishing Sectors

The questions raised in the preceding paragraph are restrictive in that they leave out the effects that other sectors might have on fisheries. The objectives of fisheries development include increased income for fishermen in order to increase their effective demand and increased fish production in order to make additional protein-rich food available to Nigerians. Achievement of these two objectives may be easier if we look beyond the fisheries subsector. For example, many fishermen may find employment in the agricultural sector as farmers or in the industrial sector as unskilled laborers. Development in agriculture, especially the food crops subsector, may keep part-time fishermen too busy to fish. Such alternative sources of income may reduce the number of fishermen, particularly in the canoe component, to such an extent that competition for fishing grounds is reduced. This reduction in competition may result in increased catch per fisherman or per boat unit. Assuming that prices do not fall, there may be increased income for the remaining fishermen without a reduction in production.

In view of the above, we therefore need to conduct investigations into alternative sources of income and protein-rich food production.

It will be necessary to include agronomists, plant breeders, input/output analyst, and soil scientists in our team in order to investigate the possibilities of introducing the kind of swamp rice variety introduced in the brackish waters of the Mekong Delta region of Vietnam in 1965. This rice variety grows on cat-clay or acid-sulphate soil. We need to determine the salinity of our brackish waters especially in the Niger delta area: this will require the services of a soil chemist. Another variety of rice that we will like to investigate is the floating rice variety which is grown in Thailand, Cambodia, and Vietnam. Further, we would investigate the possibility of planting bananas, plantain, and "akuro" yam on a commercial basis in the coastal regions where fishing is at present the main industry. Information obtained from these investigations may throw light on the kinds of policy alternatives that will best achieve balanced agricultural and fisheries development.

There is also an immediate need for compiling a list of the kinds of jobs and employment opportunities that are open to coastal inhabitants, especially in the crude oil-producing areas. This list will also include the types of training that may be necessary for different jobs and information on where and how to obtain such training. This type of information may help policy makers in formulating training programs for the coastal rural areas' development.

Another investigation that we would conduct is the possibility and profitability of setting up cooperatives or franchises that will process fish. If this proves feasible, then the fisherman-processor will be relieved of processing and he can then devote full-time to fish catching.

These investigations will be conducted concurrently with the fisheries research project that is proposed in this thesis. We do recognize the multidisciplinary nature of this project, but we are convinced that if we are seeking meaningful and useful criteria for choice among policy alternatives, these investigations must form part of our research effort. This multidisciplinary nature of research makes GSASA, an approach that is flexible and general enough to use information and theory from several discipline, appropriate for the type of policy analysis visualized here.

Data Categories

The categories of data listed here are not exhaustive but are meant to guide planning of the field work. The categories can be divided into two broad classes--technical and social. The technical categories will include such data as biomass source in which biologists and biometricians are needed for data collection while the social categories will require the skills of economists, extension specialists, and sociologists for data collection. We have listed nine categories and the type of data in each category. The questions of how and when the data will be collected and where to find funds will be discussed in subsequent sections.

1. Biomass Source.--The first information to be obtained here is on fisheries locations. This will be a map of the coastal area showing sources of fish at different times of the year. It is known that the canoe fisheries component is heavily dependent on bonga and sawa fisheries.

Bonga fishing is seasonal. The season comes immediately following the annual floods, but it is known that bonga are available all the year round. The limiting factors are the location of bonga during the wet season, and the kind of boats that can reach the locations. The same is true of sawa. We need to obtain information on movements of bonga and sawa, for example, during at least a full-year cycle to ascertain potential yield and estimate the rate of exploitation that the stocks can sustain. Specifically we need the following information:

i. distance of fishery from fishing village

ii. time needed to get to and from fishery

iii. migration patterns of the fish (e.g., bonga, sawa)

iv. maximum sustainable yield of the fishery

v. natural rate of death of fish

vi. rate of catch or exploitation

vii. rate of fish population growth

viii. breeding locations

ix. size distribution

x. food and feeding habits

xi. fish species found

The data in this first category are best handled by biologists who specialize in the areas of population dynamics and/or biometrics. The biologists usually take samples of fish with special equipments as they travel along the coast in specially constructed boats. They take days and sometimes weeks on the sea collecting samples at different locations. Their analyses will result in the determination of the data listed above. The process requires heavy investments in boats, gear and nets, and personnel. The Federal Department of Fisheries has a fairly established process of collecting these data and this study will depend on the department for collecting such data. The work of the economist is very limited in this category which will be handled by the fish source group.

2. Data on Physical Production or Input-Output Information.--After we have established or ascertained potential biomass, its location, and exploitation regulation, we can then consider data on the actual process of catching. While category 1 looks at the data requirements for "fish growth" (Figure 4.3), category 2 considers data requirements in "harvesting."

This category includes information on physical inputs and physical outputs by individual boat units by categories of boats. These data will help in testing or in re-constructing the structure of the canoe component model presented in Chapter V. The information will provide the building blocks necessary for validating or redefining the functional relationships in fishing unit production (equations 5.2, 5.3, and 5.4). In addition, it will provide data for describing the present fishing system, for identifying production technologies presently in use, and for identifying resource requirements and/or demands for inputs by the boat units. Further, the information will throw light on fishermen's interaction and on their diffusion susceptibility.

Data in this category will include:

(a) number of boat units existing for each boat-category

(b) number of boat efforts (in boat-days) per boat unit

(c) production per boat effort

(d) labor requirements (in men) per boat unit

(e) family labor supply (in men) per boat unit

(f) hired labor (in men) per boat unit

(g) number of boat units required for efficient exploitation per boat category

(h) fishermen's off-fishing activities by boat category

(i) number of days spent in nonfishing activities by boat category

(j) fisherman's experience by boat category

i. number of years fishing as owner

ii. number of years fishing as hired labor

and

(k) personal data

i. age of fisherman

ii. level of formal education (length of schooling)

iii. number of years of apprenticeship

iv. source of information on fishing operations

This category will be handled by the production group.[1] The data will form part of the information to be collected by enumerators using structured questionnaires

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[1]The working teams or parties consist of marketing, production or harvesting, biomass source, processing and storage, nonfishing sources, and extension teams. Working parties will be discussed later.

and forms or record sheets. The enumerator will be trained and required to record d, j, and k only once. He will record c, e, and f daily and make weekly summaries while b will be recorded weekly with monthly summaries made. a, h, and i will be recorded only on monthly basis while g will be determined using iv. of category 1. At the end of every month all the enumerators in each fishing village will be required to summarize their data and submit summary sheets as well as working sheets to a superintending enumerator who will bring them to an area supervisor. He will submit the sheets to the economist who is the group leader. The fisherman's cooperation will be sought especially on c.

The monthly data summaries from this and subsequent categories will be used to refine problem definitions, check postulated relationships with a view to constructing a fisheries model eventually, seek solutions from the information gathered, evaluate existing policy alternatives and, perhaps, formulate new ones and to interact with policy makers. The process may lead to discovery of new needs and, hence, new problems which need to be defined more explicitly. This brings the iterative process back to the beginning. The process will continue until we have eventually defined problems explicitly, constructed models, tested policy tools, projected consequences of policy alternatives over time, and emerged with criteria for choice among several policy alternatives. The application of the selected policies to the real system will create a new system and new problems which will result in a continuing search for better policies for solving the new problems. This iterative process which is the central theme of GSASA make it (GSASA) a realistic approach for seeking solutions to developmental problems.

3. Data on Economic Factors and Constraints.--Information for this category will include data on capital and labor availability, acquisition of productive resources such as boats, gear and nets, motors, prices, and processing techniques.

The most limiting factor in canoe fishery development is money. Money is an important constraint because of lack of savings and access to loans. Savings may be lacking as a result of the large proportion of income that is consumed and because of investment in other areas, in particular, the education of children and the health of the family. Loans may be a limiting factor not only because credit facilities are not available, but also because of traditional attitudes to borrowing. Refusal to borrow may be due to aversion to risk, or to a challenge to "responsibility," or to uncertainty as to the future returns of the investment. These may lead to internal capital rationing which may be more constraining than the cost of the loan from an external source. It is also possible, actually true in many cases, that the fisherman is not well-informed about the availability of credit or loans when they are made available.

Labor availability is covered in category 2; so also is acquisition of productive resources. Price information will include the price of unprocessed fish received by the boat unit, the price of processed fish paid by middlemen, the price received by middlemen, the retail price, and the cost of transportation. Input prices will also be collected and information will be collected on a fishing unit's responsiveness to price changes.

Data on the proportion of catch sold as unprocessed fish, proportion of catch processed, proportion of catch wasted during processing and during transportation will be collected. Information will also be obtained on the quality of processed fish by category of oven. This will be represented by shelf-life of processed fish.

The data in this category fall into six main groups. These are:

1. Price data which include
    a. price of unprocessed fish
    b. price of processed fish (paid by middleman)

c. middleman's price (paid by retailer)

d. retail price

e. price of meat

f. cost of transportation (middleman's cost)

g. price of storage

h. sales cost (retailer's labor)

2. Input price data

a. price of boats, motors, gear and nets by size

b. price of hired labor

c. petrol prices

d. wages paid for unskilled labor (as a proxy for family labor wages)

e. wages paid in fisheries

3. Processing data

a. type of oven

b. cost of oven

c. cost and quantity of wood and/or other fuel

d. length of time spent processing a given quantity of fish (e.g., a day's catch)

e. quantity of fish processed per month

f. number of days per month spent on processing

g. number of days per month spent on packaging

4. Sales data

a. quantity and proportion of catch sold unprocessed

b. quantity and proportion of catch sold processed

5. Household expenditure on

   a. food

   b. debts

   c. court cases (if any)

   d. consumer goods

   e. education (children's)

   f. festivals

   g. ceremonies (e.g., wedding, naming, etc.)

   h. shelter (rents if any)

6. Time series data on the preceding five groups where applicable and available from existing records and/or studies.

These data will be collected and handled by the marketing and production groups. Unlike the production team, the data collection of the marketing team cannot be handled at one point. The parts of the data that can be collected at the village level will be assigned to the enumerators stationed at the fishing villages while other price data will be collected from urban centers such as Lagos, Benin, Port Harcourt, etc.

<u>4. Information on Infrastructure</u>.--It is not enough to emphasize production of fish; we must consider how increased production will be distributed. Information

on distribution centers around the infrastructure in the canoe component. It will be difficult to improve on the existing structure without an understanding of it. Information needed for such understanding will include:

a. market locations--i.e., distance between a market and a fishing village

b. communication and transportation systems

c. storage facilities, types, number of each and locations

d. landing facilities, e.g., jetties, number and locations

e. repair facilities and other port services.

The marketing and the extension teams will cooperate in collecting the data in this category. Most of the data here will be in the form of inventories.

5. Institutional Information.--This category of data will include information on the market system and on government policies and programs.

Information on the market system will be concentrated on the structure of the market and on the conduct of the participants in it. This is to ascertain whether or not the present structure can handle a substantial increase in fish production; if not, what are the modifications that will be needed to improve it. The data on the conduct of participants will concentrate on an equitable distribution of returns to the system. In other words we will seek data to answer the question, "Are participants receiving returns commensurate to their investments?"

Information will be collected on government policies on taxes, duties, input subsidies, price controls, and information dissemination. We will also need data on the number of extension agents required and the number available for the canoe fishery. Data on fishing demonstration activities will also be collected.

The extension and production teams will work with policy makers and/or their staff to collect information in this category. Data will include:

1. Entry requirements, e.g.
   a. length of apprenticeship for middlemen, retail-traders, processors, and fishermen
   b. fees charged for apprenticeship
   c. fees charged for becoming full members
   d. qualifications for membership
2. Price margins, e.g., between
   a. producer price and processor price
   b. processor price and middleman's price
   c. middleman's price and retail price
   d. middleman's cost and middleman's price
   e. retailer's cost and retailer's price
   f. producer cost and producer price

3. Government taxes and duties (if any) on, e.g.,
    a. boats
    b. gear and nets
    c. fish landed
    d. petrol
    e. income (e.g., flat rate tax)
    f. ice plants
4. Input subsidies on
    a. petrol
    b. credit and loans
    c. acquisition of boats, gear and nets and other equipments
5. Information dissemination
    a. number of innovations proposed]e.g., new gear and nets
    b. number of innovations underway
    c. number of extension agents in each fishery
    d. number of fishermen in each fishery
    e. length of time an extension agent spends with a fisherman
    f. number of fishermen and/or fishing units that adopted an innovation from extension agents
    g. number of fishermen and/or fishing units that adopted new ideas from other fishermen
    h. number of fishing demonstration units provided by government or private firms

i. number of demonstrations by the units in each location per month

j. traditional or local information dissemination patterns.

6. Human Information.--Methods of fishing in the canoe component are traditional. Attempts have been made in the Western State to transform from manual to modern motorized propulsion of boats. Only .3 percent of the fishermen adopted the new method. No attempt will be made here to speculate on reasons why the attempt failed, but, since breaking away from tradition is a difficult process, we need to collect data on the belief system of the canoe fishermen. An understanding of the people's attitudes, norms, values, beliefs; i.e., understanding the belief system may result in re-interpreting the beliefs in a way which is conducive to change. From the belief system it may be possible to discover the factors and incentives that will result in their responsiveness to technological changes. The information in this category will also include family characteristics such as attitude to children working or going to school or to the big cities, family size, responsibility bearing, and decision making within the family.

The approach we will use here will be similar to the approach used by the KASS team in Korea. We feel that by interactions among investigators and decision makers and among investigators, village leaders, and fishermen we will be able to collect data in this category. The role of the extension team will be important here. Data will include:

i. family size

ii. ownership of resources, e.g., boats, gear and nets, labor services

iii. attitudes to adoption of new techniques

iv. reasons for adoption/nonadoption of new techniques

v. attitudes to formal education

vi. attitudes to migration to urban centers

vii. attitudes to continuance of fishing as a family profession

viii. attitudes to replacement of fishing by nonfishing activities

ix. aspirations for self (i.e., fisherman) and children

x. responsibility bearing within the family (a form of informal social insurance)

xi. decision making within the family and among families within a village or community

xii. attitudes to cooperation and leadership roles within a community of fishermen

xiii. attitudes to government activities (e.g., extension, credit, and loan programs)

xiv. fishermen's attitudes toward separating fish catching from fish processing.

7. Social Amenities.--Availability of labor is dependent on the state of health of the fishermen and on their contentment with respect to living in their communities. It is recognized that we cannot measure contentment without some index but if we collect data on the things that make a village or a community a good place to live we may have an idea of contentment.

The data in this category will be collected and handled by the extension team. Data will include

a. education facilities

i. number of primary schools

ii. number of primary school teachers in each school

iii. level of education of the primary school teachers

iv. enrollment in primary school by villages

v. number of secondary schools

vi. number of secondary school teachers

vii. enrollment in secondary schools

viii. enrollment in universities (number of villagers who have left to attend universities)

b. Health facilities

i. number of dispensaries in each village

ii. number of maternity centers

iii. number of medical clinics and/or mobile clinics

iv. number of hospitals

v. numbers of dispensary attendants, nurses, midwives, doctors, etc.

vi. number of public health centers

vii. number of nutrition and child-care programs

viii. number of villages with pipe-borne water and electricity

c. Entertainment facilities

i. number of community centers

ii. number and list of games played

iii. number of cinema theaters

iv. number of mobile cinema shows

v. number of bars, club houses, etc.

8. Data on Income.--There will be two types of income on which data will be collected. These are income, in kind, and cash from fishing activities and from non-fishing activities by fishing households. This will enable us to determine the relative income position per household, the proportion of it that comes from fishing

activities and how the income compares with the rest of the nation. The production team will be responsible for this category of data which will include:

i. quantity and value (in naira) of fish set aside for household consumption or received in payment for services rendered

ii. quantity and value of gathered food for household use

iii. quantity and value of food raised at the backyard

iv. income from fish--unprocessed and processed

v. income received working as a hired hand in fishing

vi. income from nonfishing activities such as working as a laborer, farmer, hunter, trader, artist (handwork and crafts) wine tapper, etc.

9. Potential Alternative Sources of Income.--
The data in this category will include information on:

i. unexploited fisheries

ii. list of crops that are raised and can be raised but not raised presently

iii. sale prices of crops listed in ii

iv. market potentials of crops listed in ii--demand and supply of such crops in other parts of the country

v. training opportunities in other sectors of the economy--length of training, cost of training, and income on completion of training

vi. number and types of unskilled labor jobs available to fishermen

vii. number and skilled labor jobs available to fishermen, i.e., jobs for which they already have the required skills

viii. wages paid by nonfishing firms

ix. number of immigrants in the fishing village

x. number of migrants from the fishing village

xi. number of return-migrants

xii. cost of migration--costs of transport and maintenance before finding a job

Data Collection

The data listed above can be obtained through a cross-sectional survey which, hopefully, will form a basis for establishing a permanent data-collecting mechanism in the state ministries of agriculture and coordinated by the Federal Department of Fisheries and the Department of Agricultural Economics, University of Ife.

Figure 6.1 shows the diagram of a nested sampling design to be used for data collection. The plan is to divide each of the maritime states into administrative or research divisions. The existing political divisions

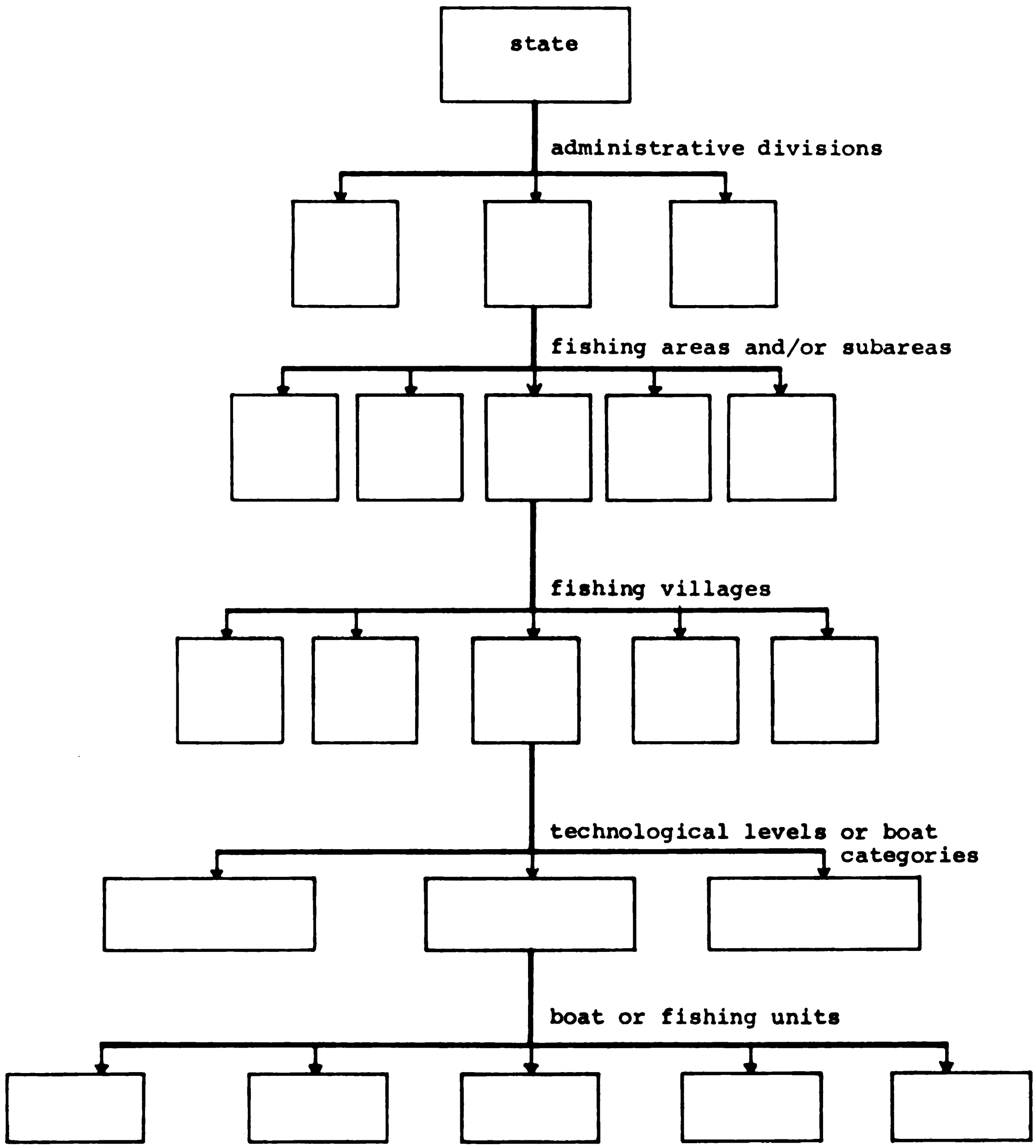

Figure 6.1: Nested Sampling Procedure

will be used unless a better stratification procedure is discovered during the early stages of the study. Each division will be stratified into fishing areas or subareas; the stratification will be based on the fisheries that are identified as important biomass sources. Within each fishing area, we will compile a list of fishing villages from which a sample will be drawn. Each selected fishing village will be stratified into boat categories or technological levels. We will then compile a list of fishing and/or boat units within each boat category and draw a simple random sample of boat or fishing units from it; this will be our primary sampling unit.

The sample size will depend on the number of fisheries located and determined viable, personnel availability, the ease of access to fisheries areas, the availability of funds, time constraints, the level of accuracy of information desired, the costs of obtaining and processing data, and the value and utility of the information which we are seeking.

In determining our sample size we will use the principles of Chebyshev's inequality and the law of large numbers.[1] In using these we only need to state

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[1]The reader is referred to any statistical methods textbook, e.g., Introduction to Statistical Analysis by W. J. Dixon and F. J. Massey, published by McGraw-Hill Book Company, Inc., N.Y., 1957 (pp. 292-93), for detailed discussion.

the level of confidence which we are willing and ready to put on our estimates. In this study we will take a sample size, n, which will ensure, with a (100-a) percent confidence, that our estimates will not be farther than k standard deviations from the true value. In other words, we will set the probability of committing a type I error, the error of accepting a null hypothesis when it is false, at "a" percent. Both k and a will depend on the factors mentioned above because k and a determine n. The following formula will be used to compute n once k and a are set.

$$n = \frac{k^2}{a}$$

where k is number of standard deviations and a is the probability of committing a type I error. The importance attached to each fishery or area and to the information on it by the government will determine the values of k and a.

After the sample size for each area is determined, the relative sizes (in terms of fishermen population) of the selected villages will be used to determine the number of boat units that will be selected in each village. The village samples will be organized to include all boat categories in each village. Even though our primary unit of study is the fishing unit, data will be collected from each participant within the unit.

Questionnaires and data forms will be designed on the basis of the data categories discussed in the preceding section. The working teams will design forms and questionnaires for their various categories. The completed forms will then be presented at a meeting of all groups for exchange of ideas, following which some forms and questions may be modified. Then there will be a trial run during which the forms and questionnaires will be tested in a few fishing villages not included in the sample. This exercise is to detect and correct any inadequacies in the questions asked and in the recording of information on forms before actual data collection is started.

Collection of market information will follow a different pattern. Village level market information will be collected along with other data collected from fishing units. The market centers described in Chapter I will be used as points of price data collection, especially retail prices. Data on the quantity of fish that reach these markets, Lokoja, Ibadan, Warri, and on prices of meat and stockfish will be collected. These data will be collected at three levels; namely, village, middleman, and retail levels. The village level information will be collected by enumerators located in the villages while the market enumerators who will be assigned to market centers will collect data at the middleman and retail levels.

In addition, we will collect information on the wages paid by nonfishing firms or enterprises in the fishing areas, and on the ease or probability of fishermen finding jobs in these firms (detailed data list is given in category 9). Of particular interest are petroleum companies. This information may provide insight into migration, alternative employment possibilities, and opportunity costs of moving out of, or staying in fishing.

The first set of data will be cross-sectional data, but since we will collect data summaries on a monthly basis, we will, by the end of the first year of the project, be able to compile a twelve-month time series data.

Data Processing

The data processing center will be located at the University of Ife. As the data forms and questionnaires are returned at the end of every month, the information contained will be coded on IBM coding sheets and punched on cards. Summary tables will be prepared for the use of the working groups which will be responsible for interaction with policy makers and for preparing working papers on the groups' sections. The working papers will be used for interaction purposes. A more detailed discussion of data processing is given in Stage IV in the next section.

Stages of the Study and Plan of Operation

The feasibility considerations discussed in Chapter III were broad and general. Operationally, we need to address ourselves to the question: For what geographical area and/or group of people is fishing a feasible alternative in Nigeria? Further, we need to know what type of fishing is, or will be, most lucrative and for which group of people. These questions must be examined in terms of biomass availability, marketing, and processing facilities, technology of fishing, effective demand for fish, fish prices, alternative income opportunities, etc. Stage I of our procedure will be directed to answering these and similar questions. Stage II will be devoted to data collection. There will be six stages altogether, but because of the iterative process of GSASA it is difficult to divide the six into exclusive stages. For example, information obtained in stage II may be used to redefine the problems that are identified and defined in stage I. Stage III which will deal with modeling will begin as soon as information starts coming in on the structure of the system, i.e., as soon as stage I begins. As stage III progresses the experience gained in the modeling may be useful in refining the procedures and the types of data of stages I and II. In stage IV we plan to perform statistical analysis and test runs. At every stage there will be interaction between investigators and decision makers. The information obtained in stage IV, which will include estimates of parameters and endogenous variables and projections, will be useful for interactions with policy makers and for refining models, problem definitions, and for better understanding of the system. In essence, stages I through IV will complete GSASA stage I and part of its stage II. The fifth stage of the study will be devoted to formal interaction among decision makers, investigators, and itinerant researchers and consultants. This stage is part of the analysis block of GSASA stage III. All the information obtained in the first four stages of the research project will be discussed, evaluated, and a set of development policies agreed on. This stage will take the form of a seminar. These policies will then be simulated (stage II of GSASA) and time paths of consequences of different policies obtained as a means of arriving at criteria for selecting among several policy alternatives. This is stage VI of the study. This stage will not be completed until RCPM (Figure 2.1) is obtained, i.e., until a set of policies and programs (P of Figure 2.1) designed to solve fisheries developmental problems are obtained. These policies and programs will then be applied to the real or perceived system but the application and evaluation of policy and/or program performance will be the subjects of a follow-up research work.

It must be emphasized that this study will be a joint effort of university-based researchers and the decision makers and their staff. Apart from the formal interactions planned in stages I and V, the policy makers participation in every aspect is essential. To ensure this participation, each working group will include representatives from the federal and state divisions of fisheries.

Stage I: Preliminary Investigation

The first stage of this project can be summarized as the identification phase. In this phase we will seek answers to "what," "where," and "who" questions. The objective of this stage is to find answers to the questions, at least in part: Is fishing, relative to other employment opportunities in an area, a feasible alternative? If so, where and for whom is it feasible? What are the feasible technologies for both harvesting and processing? The answers to these and similar questions will help guide governmental policy and private investment decisions.

The first "what" question is: What do we have in terms of fisheries resources? This is like taking an inventory of our fisheries and thus identifying biomass availability. This identification of fisheries will help in evaluating which fisheries are large enough to support intensive or extensive exploitation. This phase of stage I will cut across political boundaries in that we will be seeking to identify fish sources for the whole nation. Identification of fisheries or fish sources and migratory behavior of fishes will help us determine where the fish are and where they may be at different times of the year. We will also identify the types or species of fish that could be found at each source.

Having identified the geographical locations ("where" question) of the fisheries, we will know or be able to identify the people who exploit or may be able to exploit them. This brings us to the questions: What is being done to the fisheries and by whom? Is fishing a feasible and viable source of income for the people in this place?

Up to this point, we will rely heavily on existing biological research work of the Federal Department of Fisheries, the Food and Agriculture Organization of the United Nations, and the USAID. It may, however, be necessary to conduct further biological research into the fisheries. This will be done as the need arises, but we do not visualize such need now.

At this point, we would have identified all the fisheries and their locations, and the ethnic groups that exploit or depend on them. The next phase will be identification of economic activities of the people.

This will be followed by identification of fishing technological levels for each area, listing of boat, gear, and net categories, and identification of sources of inputs and their costs. We also seek information on the proportion of available labor expended on fishing activities and nonfishing activities.

Sources and levels of income will be listed with a view to determining the most important sources of income. This will include fishing and nonfishing sources. With information on levels of income in each area, we will be able to compare the incomes made by a fisherman with incomes made in other sectors of the economy. This with information on fishermen's patterns of expenditure on food, consumer goods, education, etc., will shed light on the fishermen's effective demand.

Information on food is of particular interest. The inter-relationship between good health and good food is an established fact. The problem of malnutrition has been discussed in Chapter III. It will be informative, particularly in evaluating the quality and quantity of available labor service in a given or identified fishing area, to determine whether the fishermen and other inhabitants of a fishing area are malnourished or undernourished. If the emphasis is on "fish for the market" there may not be enough left-over for adequate nutrition for a fishing family, unless there are other sources of protein-rich food which are cheaper than fish.

In each fishing area, we will compile a list of processing methods. This list will include traditional methods which are in use and those no longer being used, modern methods which are adopted and/or adapted for use, and those that are not adopted. We will obtain information on cost of processing and shelf-life of fish processed by various methods. Marketing facilities and distance of each fishing area from "high fish demand" areas will also be determined.

Another question we will address ourselves to in this stage is: What alternatives, other than fishing, are open or can be made open to the inhabitants of each fishing area? These alternatives will include income and employment opportunities, food sources, and migration. The kinds of investigations that will handle this aspect have been discussed in the preceding section.

At this point we will have a perception of the system (i.e., we will have the "perceived system" of Figure 2.1) and the working groups, in cooperation and interaction with policy makers and their staff, will be in a position to evaluate the data categories discussed in the preceding section, and modify them in the light of new information obtained in this stage. They will also be in a position to make a decision on the values of k and a and to construct questionnaires and forms.

The next phase of stage I is a preliminary seminar. The seminar will be attended by the members of the different working groups, policy makers, and their staff and consultants. The objective of this early meeting is the interaction among investigators, policy makers, and experienced researchers to provide a forum for constructive critical appraisal of the research project and its perception of the system. This interaction may lead to modification of questionnaires, redesigning of forms, redefinition of values, recomposition of working groups, and formulation of policies that will guide governmental and private investment decisions while more information is being sought in the subsequent stages of the study.

This seminar is expected to take place between six to nine months after this writer has returned to Nigeria and started the project.

Stage II: Formal Data Collection

The second stage of the study will consist of data collection on a more formal basis than the stage I data and nonfishing sectoral investigations in the identified fishing areas. Successful execution of stage I may result in raising questions on data and policy alternatives that had not been considered or thought of. Such information as may be obtained from stage I will therefore be used in modifying the types of data that will be required for our model and policy formulation. The data categories discussed earlier in this chapter assumed, for example, that we have identified a bonga and/or sawa fishery, that the fishing is done mainly in the canoe component, and that all the data categories refer to only one area or location of bonga fishing. These assumptions would have been verified and modified or rejected at the end of stage I.

The objectives of stage II are to provide cross-sectional data to estimate values of parameters and endogenous variables for operationalizing the model proposed in chapter V and to provide a framework on which to base regular data collection for policy formulation, refining or retooling and validating our model, and establishing a data bank which can be used for constructing an input-output table for the fisheries subsector. The data collected here is the "data" referred to in Figure 2.1.

Stage III: Modeling

The third stage of this study is modeling. In Chapter IV we conceptualized the structure of the fisheries subsector (Figure 4.1) and of a component of it (Figure 4.3); with the information obtained from a successful completion of stage I and the beginning of stage II we will be in a position to confirm or modify our conceptualized model. As we accumulate data from stages I and II, we will be in a position to examine the relationships postulated in Chapter V. Some of the equations may be validated, others may need modifications, some may have to be replaced by new relationships, and it may be found necessary to construct additional relationships to the existing ones. This modeling will be performed concurrently with stages I and II. The writer will continue to work on the modeling in consultation with the project consultants and other members of the working groups.

We envisage that stages II and III will take about 18 months to complete.

Stage IV: Data Analysis

The fourth stage will be devoted to data processing, statistical or econometric analysis for estimation of parameters, and initial values of endogenous variables. We will also carry out test runs of the model as a means of testing the workability of the model and the performance of policy alternatives. We will also make projections of endogenous variables over time.

The data collected in stage II will be summarized and used as a means of understanding the structure of the fisheries and making projections. This may enable the researchers to construct explicit or structural equations which could be analyzed with econometric procedures of parameter estimation and hypothesis testing, or any other feasible technique. Most of the data problems raised earlier would be removed with the availability of cross-sectional and time series data.

If we could build these data up for each component, we would not only be able to show the structure of the industry, but we might also be able to use the data to generate statistical information which could be used to construct national accounts which we do not have at present on the fisheries subsector.

If we could obtain the data collected by FAO between 1961 and 1965 on Nigerian fisheries, we could use them as one set of data and our data as a second set. Since the collection of our data will start in 1973, there will be about ten years interval between the two sets of data. We could then simulate data for the intervening years. If we could thus generate data on prices, quantity of fish produced and consumed, income, migration, etc., we could possibly generate an input-output table for the subsector. This would be an asset for policy analysis for Nigeria's fisheries subsector, because at some future time, we will need this table (input-output) for the interactions with other subsectors of the economy. In addition, basic data will also be needed by decision makers (e.g. the director of the Federal Department of Fisheries) in writing their annual reports on the performance of their department and divisions of fisheries, to justify continued allocation of government funds to their subsector.

These data (FAO's) can be obtained from either the FAO headquarters in Rome or from the fisheries divisions of the Ministries of Agriculture and Natural Resources of the Western and Midwestern states. We will contact both sources to obtain the data.

At the end of this stage which will take 6-9 months, each working party will be asked to form subgroups to write working papers on their various subjects. The working papers will form the basis of the next stage.

Stage V: Seminar

The fifth stage will be a seminar to be held at the University of Ife or at the Federal Department of Fisheries in Lagos. Participants in the seminar will include members of the different working groups, project consultants, representatives of F.A.O., USAID, and other agencies that indicate interest in the project, the staff of the Federal Department of Fisheries and state divisions of fisheries, other federal government agencies involved in fisheries policies, and private fishing business representatives.

At this seminar, those who are working directly on the study will present findings on the consequences of policy alternatives that may have been tested.

In essence, we will discuss the results of stages I through IV with the decision makers, private and public. Such interaction will, hopefully, result in a basket of policies on which policy simulation could then be performed.

Stage VI: Policy Simulation

The sixth stage will be policy simulation, the output of which will be a set of criteria for choice among policy alternatives.

At the completion of the sixth stage of this study, a follow-up project will be recommended. The project will be designed for continuing the data collection process which will be established with successful execution of stage II of our study, for testing new policies, for continuous evaluation of the performance of existing policy alternatives, and for continuous model building and validation.

Research Team and Funds

The research team will consist of seven research groups which will be organized along broad subject areas. These groups are (1) fish source, (2) harvesting or production, (3) marketing, (4) nonfishing income sources, (5) extension, (6) modeling, and (7) consultants. Six of the groups will each be headed by an economist who has an interest and expertise in the subject area. The first group will be led and directed by the director of the Federal Department of Fisheries, who is a specialist in fish population dynamics studies. In addition to the group leader, there will be one staff member from the FDF planning division and one from the states' divisions of fisheries in each group. Each group will have a consultant who will be involved in planning the collection and analysis of data and in the writing of working papers. He will also take part in the seminars. Each working group, except the first, will have field staff which will comprise area supervisors, village supervisors, and enumerators.

Fish Source Group

This is a technical group whose work will be very important especially in the stage I of the study. The members will be fisheries biologists from the Federal Department of Fisheries and the states' fisheries divisions. It may also include experts from FAO and USAID who have done similar work for the government of Nigeria. The composition of this group will be left to the director of fisheries to determine since he is our expert on biomass studies.

Harvesting or Production Group

Dr. Sam Olayide of the University of Ibadan had indicated interest in working with this group. He will work with this writer in organizing and leading the group. The group's primary focus will be on harvesting and processing blocks of the canoe fisheries component. The group will supervise data collection and analysis, write working papers, and present the papers at the seminar which will take place in stage V. Working with the group leaders are one supervisor of data collection in each area, one superintending enumerator in each village, and one enumerator per three to five fishing units in each village. The area supervisor will be responsible to the group leaders and will be a graduate assistant or an agricultural superintendent.

Marketing Group

Like the production group, the marketing group will be headed by an agricultural economist and its work will be similar to the former groups except that the focus will be on the marketing aspects of the canoe component. This group will include a geographer.

Nonfishing Income Sources Group

The work of this group will be divided into two parts. The first part will deal with collection and analysis of data discussed in category 9 of "data categories" and will be organized along similar lines as the other groups' work. The other part will concentrate on biological studies of the feasibility of introducing new food crops such as floating rice to the fishing areas. This involves taking soil samples and performing plant breeding experiments, first in the laboratories and then on the field. Consequently, this group will consist of plant breeders, soil scientists, extension specialists, and economists. Tunde Fatunla of the Plant Science Department and Wale Adebayo of the Soil Science Department, both of the University of Ife, expressed interest in working with this group. The MSU employment generation group, especially Dr. Byerlee, may also be interested in this group.

Extension Group

Members of this group will be drawn from the extension specialists of the Universities of Ife and Ibadan. They will work on all the extension aspects of the study.

Modeling Group

Dr. Olayide and Dr. Afonja and this writer will work, in consultation with Dr. Manetsch and Dr. Abkin, both of MSU, on the model building, testing, and validation. The University of Ife computer will be used by this group.

The project consultants will include Prof. Glenn Johnson, The Director of MSU-Simulation project, Prof. Manetsch, Dr. Abkin, both of MSU and FAO and USAID experts. The MSU-Simulation project members have indicated interest in the study but we have not contacted the FAO and the USAID. It must be added that the Federal Department of Fisheries has indicated a definite interest in the study.

Sources of Research Funds

There is no commitment on funds at present but, based on the interests indicated by various groups, especially the FDF and the MSU-Simulation Project, the funds will be sought from the Federal Government of Nigeria and the USAID. Other sources of funds that will be contacted include the FAO and the Rockefeller Foundation. A crude estimate of the funds that will be required for the study is about 336,000 naira (U.S. $504,000) for a three-year period.

Summary

In this chapter, the need for data was discussed. This was followed by a discussion of research needs in terms of data requirements of the fisheries subsector both from fisheries itself and from nonfishing sectors. A detailed list of data was presented in nine data categories and a data collection procedure was outlined. Data processing was discussed briefly before outlining the stages of the study in a subsequent section. Stage I of the work is planned to last six to nine months, stage II will last about 18 months while stage III is regarded as a continuous process. Stage IV is planned to last six months while stages V and VI will be completed in about six months. The working groups and their members are discussed and the possible sources of funds were mentioned. It must be emphasized that there is no commitment to the study by the people and sources of funds listed in the chapter.

The next chapter will present a brief discussion on costs and benefits of research.

CHAPTER VII

A DISCUSSION OF COSTS AND BENEFITS

Introduction

The application of the model proposed in this thesis is a specialized research activity requiring scarce resources--highly trained personnel, special equipment, and time--and producing a valuable product--information--which is useful for guiding policy making. The information produced can result in the discovery of new equipment or materials, in finding new ways of using existing tools, and in the finding of new and more effective institutions to support and control the development of Nigerian fisheries.

Allocation of research resources should be based, ideally, on the equimarginal principle in which the marginal cost of research activities is equated to the marginal revenue from such activities. Resources allocated to research and, hence, part of the cost of research, can be easily observed and measured. This cost is the cost of acquiring the new information which is being sought by the researcher and/or policy maker.

General Discussion of Costs and Benefits

The cost of developing and implementing the model proposed here will be affected by a number of variables. These variables include (i) the number and variety of policy questions to be addressed by using the model; (ii) the accuracy required in answers to policy questions; (iii) the complexity of the system being modeled, i.e., the number of important variables, sectors and/or interactions within the system, and the degree of disaggregation desired; (iv) the stock of available statistical information about recent behavior in the system under study; (v) prior analyses of important behavioral relationships that will necessarily be considered in the model and existing projections of relevant criteria variables; (vi) the quantity and quality of available cooperating researchers and government agencies; (vii) the availability of research facilities such as computer facilities, transportation, and the communication facilities in the area; and (viii) the amount of time allowed to complete the development of the model.

Even though field research is expensive and time consuming, there are cases, like this one, in which it needs to be done as a basis for meaningful policy analysis. This does not imply, however, that the approach is likely to be expensive relative to others. In fact, it may be cheaper than many projects that have been conducted.

After the establishment of the project at the initial costs described below, the costs of model up-dating, data acquisition, and policy evaluation would not necessarily differ much from the current recurrent expenditure on staff if all fisheries divisions and department had full complement of staff. The computer services cost may be the only extra cost to be added to the operating budget.

The benefits, on the other hand, will be a continuing stream of output useful in solving the emerging project, program, and policy problems of Nigerian fisheries. For example, reallocation of fishermen from poor fishing grounds to rich ones, and of fisheries staff, e.g., master fisherman and his teams, to working more intensively with fishermen will increase fishing output and fishermen's income. Other examples include continuous evaluation of production campaigns, the performance of demonstration programs and of projects designed to improve fish processing techniques, and the evaluation of government loans and credit policies. The credit of increased output and fisherman's income will go to the administrators who are charged with planning the development of fisheries. In order to accomplish this the administrators need the types of information that will be produced by this project. The project therefore provides an opportunity for the administrators to perform their duties adequately.

In 1960, the then Western Region asked a team of experts to conduct a comprehensive study of its fisheries. The project took five years to complete at a cost of almost one million dollars (actually $982,226) (19) compared with our project which is estimated to cost about $504,300 in three years.

Even though the estimated cost (in monetary terms) of our project is lower than that of the one mentioned above, we cannot compare their values because the value or benefit which research renders is often very difficult to measure. This value includes, for example, the satisfaction which a researcher obtains either in the form of professional recognition, e.g., award of fellowships, prizes, or in the form of his perceived contribution to the development or improvement of human life. This recognition has private utility.

More importantly, the values from this proposal also include public benefits such as providing information for guiding development planning and choice of policy alternatives. These values are not easily reducible to money or other quantifiable measure which can make interpersonal comparison valid. Consequently, we encounter difficulty in aggregating the values obtained into "total benefits" from the research project. The lack of a valid common denominator makes it difficult to use maximizing techniques to determine optimum allocation of resources to research. Despite this limitation we can identify benefits of research and appreciate their values without quantifying them. For example, our project will provide a basis for data collection, a model for analyzing policies and programs and a process of training government personnel. It is therefore not always necessary to be able to quantify the benefits of research either to the researcher or to government or the agent which will use the information which is an output of the research project.

One output of research activity is the production of information, some of which may be private. The other category consists of information that has no private value in the sense that no one person or group of persons can claim sole ownership of it and hence offer it for sale. This category includes new ideas, new scientific information, new technical concepts, and new models and theories. This category has no private value because once it is published in scientific journals, or presented at conferences, or printed in books, the information becomes everybody's property.

The utilization of such information cannot be controlled. The first category (i.e., information that has private value) consists of information which is transformable into new skills or into new materials. When the new skill is acquired, it becomes human capital while the new material becomes nonhuman capital. Examples of new information that resulted in new skills in Nigeria's fisheries sector were seine fishing on the coast and salt-drying in the north. New materials that were introduced as a result of research efforts included nylon netting, lake chad boats, altona ovens, and Ghana boats.

It is, however, often difficult to quantify the value of the new skills or materials because the consequences and the effects of the new skills and materials will depend on existing technology, institutions, and on the human agent. The payoff on new skills, or on a higher level of skills as a consequence of advances in fisheries research is much harder to determine than for new material inputs. For example, it will be easy to compute increase in production per fisherman-year following the introduction of larger boats and mechanical propulsion; but it will be extremely difficult to separate the effects of changes in technical inputs (larger boats and mechanical propulsion) from the effects of an improvement in the quality of labor (e.g., new skills acquired to operate the new technical inputs).

A further problem in evaluating research output is estimating the time-lag between acquisition or discovery of new information and acceptability or utilization of such information. This time-lag can be worked into our model in evaluating consequences of alternative policies. We can also use our model to generate and study time paths of different policy alternatives designed to attain different "goods." This type of information, the time paths in attaining different goods, will provide the decision makers, e.g., the director of fisheries and the permanent secretary of agriculture, the basis for writing up a five-year development plan for different components of fisheries. The fisheries director can use the information in interactions with other directors (livestock, forestry, and agriculture) while making a case for allocation of funds to his department. This will provide the permanent secretary with information on consequences of several alternative policies in fisheries; and this will enable him to relate this information to similar information from livestock, forestry, and crops subsectors. He will also be able to obtain a total picture of the agricultural sector through the construction of input/output tables. These types of

information will be useful for interaction with other permanent secretaries during overall planning of the national economy. The head of a ministry (a commissioner or minister) or the governor of a state whose staff members are able to provide him with information of this type will be able to present a sound case for federal (or state) allocation of funds to his ministry or state. Because he is able to show the results of previous, present, and projected projects, programs and policies of his ministry or state, he will be regarded, and correctly too, as a good administrator. This project provides such an opportunity for administrators in agriculture and natural resources to obtain information necessary for interactions with administrators from the other sectors of the economy besides being able to perform their duties more efficiently.

Even though the value of research output cannot be determined easily, demand for it will increase as the economy grows. For example, as modernization of Nigerian fisheries proceeds, the need for information and, hence, the demand for the contributions of fisheries research will become stronger because fisheries will become more commercialized in order for the production to keep pace with fish demand. In order to direct this modernization in a way that is conducive to the overall economic development program, the policy makers need information to guide their decision making. In addition, as advances in science proceed, especially in the recognition of the need for multi-disciplinary approaches to research, fisheries research possibilities will be enhanced, thus setting the stage for obtaining additional new information from fisheries research. Furthermore, in order to interact with sectors of the economy the decision makers need to compute national fisheries accounts.

In short, the research project proposed here will give an overall view of the structure of the fishing industry; provide improved data collection process; tie the different components of agriculture, forestry, livestock, and fisheries through input/output tables to the entire economy; provide information to compute national fisheries accounts; and build for the government a model which is repeatable at low cost for evaluating project, policy, and program problems and performance. It will also provide a solid basis for cooperation between FMANR and the universities. These benefits will be discussed in more details later.

It is obvious from our estimated costs (Table 7.2 in the next section) and from FAO's report (19) that the cost of information is dependent on the price (salary) of researchers, on the price of research facilities, and on the political situation in the country. Many of the researchers who will participate in our proposed project are already being paid by the governments or the universities, thus eliminating the cost of their services under our assumption of providing their services within their job obligations. The cost of developing new materials will be small because existing materials from other works--e.g. CSNRD and Nigerian simulation models--can be adapted very easily for use in our model. If we can reduce cost without reducing the benefit over time, then the rate of return will likely be higher than it would have been if cost were not reduced.

There were many research projects carried out on Nigerian fisheries but many of them are of limited use for overall national planning because they are either restricted to biological studies or to a limited area of the country. An example of such projects was one conducted on behalf of the then Western Region. This project was restricted to what is now two of the five maritime states (Western* and Midwestern) because only these states (one region at the time of request but became two regions two years later) requested it. One new piece of information from the research effort

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*Western State report included parts of Lagos State.

was a confirmation of the abundance of prawns off the Nigerian coast. The abundance was established earlier by members of a USAID project. In terms of new material, the project came up with improved ovens, altona, for smoke-drying fish. In terms of overall national development, the project provided little information. Though the project provided some detailed information for some fishing areas, it is impossible to compare productivity in the Midwestern State with that of the Western State because production was given on a per fisherman basis for the West and on a per gear-unit basis for the Midwest. This reflects the different emphasis of the state governments. The Western State government was interested in production per fisherman, while the Midwest was interested in the gear-unit production. Consequently, the form that the report of the project took was intended to satisfy the two governments and not for national comparison of results. The report devoted more than half of its research efforts and time to prawn fishing, and did not treat tuna at all. Thus, the information it provided is of limited use to a decision maker who seeks information on the entire fisheries resource. This may be a reflection of the composition of Nigerian fisheries divisions and departments.

On the other hand, our project will not only collect information on all fisheries resources in five

maritime states, but it will also analyze the consequences of alternative fishery policies with a view to providing criteria for decision making.

Of particular interest is the Western State fish pond policy which has been criticized severely by the National Agriculture Advisory Committee (NAAC). Presumably, the policy was based on research reports from the Panyam fish farm and on the recommendations of researchers. Through this program, 120 ponds were established for individuals, cooperatives, and communities. In most cases the government chose the pond site, financed its construction, stocked it with fingerlings, and even fished the ponds on behalf of its owners. The cost of dam construction alone was about 600 dollars. The costs of stocking and fishing are additional.

It is known that a successful fish farm requires properly trained fish farmers and qualified technical advice on species and dam or pond construction. It also requires effective demand for its products if it is to operate profitably. Furthermore, research must be undertaken to determine species combinations suitable for a particular environment, optimum rates of stocking and fertilizer and feeding combinations. NAAC claimed that there was little evidence that the various state governments considered these factors before embarking on their fish farming programs. We can neither justify nor refute this claim because we have no data on fish farm productions; costs of production, processing, and sales; and costs of government services other than cost of dam construction.

In spite of criticisms of the policy, the Western State government allocated about 1,485,000 naira (about $990,000), about 55 percent of its total planned expenditure on fisheries, to the continuation of its fish farming program in the 1970-74 development plan period. The type of analysis proposed in this thesis might have helped to prevent such criticism because the consequences of the policy could have been projected and evaluated before the program was adopted.

This policy is not peculiar to the Western State alone. Table 7.1 shows the national distribution of planned expenditure in fisheries and the corresponding contribution of various fisheries components to total production in 1970 and what is expected by 1985. This expenditure of about 10.6 million naira is only government's general support to investment; it does not include 3.4 million naira to be invested in fisheries by the federal and state ministries of industry.

What is the rationale behind allocating 13.6 percent of available resources to a fisheries component that produces only .05 percent of the total fisheries output and is not expected to do better in the future?

Table 7.1

Percent Distribution of Funds and Contribution to Production

Fisheries Component	Percent Distribution of Government Expenditure	Percent Contribution to Total 1970 Production	Expected Percent Contribution to Production by 1985
Marine fisheries (including distant-water)	62.1	4.1	47.1
Canoes	15.8	54.1	33.3
Lake Chad	4.0	20.2	10.3
Rivers (including Kainji Lake)	4.5	21.3	9.1
Ponds	13.6	0.2	0.2
Total	100	100	100

Source: Fisheries Report, 1972 (53).

The stated objective of Nigeria's fishery development is to increase domestic production. It may be added that there are even other objectives such as increasing fishermen's income and productivity. Is this disproportionate investment in pond fishery the answer? Are more people involved in pond fishing than canoe fishing? What is the opportunity cost of such a program? What will be the consequence of scrapping pond fishing and investing the 13.6 percent of the available investment in canoe fisheries? These are some of the policy questions that can be addressed by our model.

The discussion of costs and benefits have been made general up to this point but the next section will deal with specific costs, both measurable and unquantifiable, and benefits which are generally unquantifiable in monetary terms.

Discussion of Specific Costs and Benefits

The following is a very rough estimate of the cost of our project. In this estimate let us assume that government agencies--the Federal department, and state divisions of fisheries--will provide the project with personnel in order to reduce the cost and contribute the prior knowledge which they have obtained through the experience of working with the system.

For our purposes let the project research staff be composed of six economists (production and marketing), a fisheries biologist with quantitative skills, a system scientist as a consultant, a biometrician or a statistician, an extension specialist with communications background, six fisheries officers, six graduate research assistants, ten superintending, and fifty enumerators.

The cost of the services of the above staff will be approximately 450,300 U.S. dollars for three years (Table 7.2). The consultant service is computed at $11,000 which will cover a four- to five-month stay, four trips to and from Nigeria and other expenses, the fisheries officers at $3,000 each, the graduate assistants at $1,800 each, the superintending enumerators at $1,080 each, the enumerators at $720 each, and the remaining members at $7,500 each per year. This computation is based on the assumption that all members of the team will be Nigerians except the consultants and the system scientist. It is also assumed that the lower-level personnel will be provided by the government agents already financed. Apart from the personnel cost it is estimated that the following additional costs will be incurred over the three years: $10,000 for consultant trips and other services, $30,000 for supportive services, $20,000 for transportation, and $4,000 for

Table 7.2

Estimates of Cost of Project for Three Years

	Estimates
1. Personnel:	
*six agric. economists at $7,500/yr. each	$135,000.00
*one fisheries biologist at $7,500/yr. each	22,500.00
*biometrician/statistician at $7,500/yr. each	22,500.00
*extension specialist at $7,500/yr. each	22,500.00
*six fisheries officers at $3,000/yr. each	54,000.00
system scientists (consultant)	11,000.00
six graduate research assistants at $1,800/yr. each	32,400.00
ten superintending enumerators at $1,080/yr. each	32,400.00
fifty enumerators at $720/yr. each	108,000.00
other consultants (trips, etc.)	10,000.00
2. Other costs:	
supportive services	30,000.00
transportation	20,000.00
computer services	4,000.00
Total	504,300.00
From Nigerian sources (*)	256,500.00
From outside sources (to be sought)	247,800.00

computer services. The total annual cost of the project is estimated at approximately $168,000.

If, however, we deduct the wages of the Nigerian senior members of the team because they are already being paid either by the government or by the universities and their salary represents part of government or university recurrent expenditures, then the actual additional cost of developing and implementing the model is about $83,000 per year and $250,000 in three years which may be provided, in part, through foreign aid. This reduction by more than one-half the cost assumes that the Nigerians on the project can provide their services as part of their current job obligations, otherwise the cost will remain at $168,000 per year.

The continued funding of the project will be based on its performance after the first year. This implies that the funding for the second year will depend on the project's performance or achievement during its first year of funding.

Apart from the monetary costs discussed above there are other costs that may not be directly observed. These include costs, direct or indirect, incurred by the ordinary citizens, the fishermen, the investigators and/or their universities, and the government.

The costs that the ordinary citizen will incur are generally indirect opportunity costs in the sense that resources expended on the project could be used on other projects such as food crop production, for example. Whatever benefits that will accrue to him from such a project are given up for the benefits from the fisheries project. The cost to the fisherman will include giving up some or all of his traditional techniques of fishing; earnings given up for the time spent in cooperating with investigators to collect data and the time which he may spend in learning new skills. Some fishermen may have to seek employment outside fishing and those who are too old to move out and/or adopt new technology may be forced out of fishing to join the unemployed group.

The costs that will be incurred by the investigators can be more adequately described as university and government opportunity costs. These will include reduced teaching time for lecturers since the time they will spend on the research activities will not be available to teaching; the cost of diverting research efforts from other areas such as cash and food crop studies; cost of diversion of government staff from their routine research and administrative duties, and diversion of research funds from other areas of development activities.

The benefits that will be obtained by the ordinary Nigerian will vary. These benefits may include reduced prices of fish, ease of access to fish and fish products, and elimination or reduction of the dangers of malnutrition especially the reduction of the costs of clinically treating the malnourished, of child-life wastage; reduction in the loss of efficiency in learning due to malnutrition, and in the earnings and productivity loss in adult workers.

The benefits which the fisherman will obtain from this project are mainly in the form of information on new techniques, new materials, government policies, prices, biomass sources, and on input procurement. This may lead to increased income and eventual increase in fisherman's effective demand and better nutrition.

Apart from the satisfaction which the investigator will derive from the project, he will be able to accumulate teaching materials on the structure, conduct of participants, and performance of a primary industry in an LDC. Furthermore, he will obtain material for journal articles which will enhance his professional recognition and promotion chances.

The government which, directly or indirectly, provides the funds and the personnel will benefit most from the project because its efficiency is dependent on the quality and quantity of information which it has to work with in allocating its resources.

At the completion of this project, the government will have an expanded data base for the fisheries subsector and, with the establishment of a permanent data collection process, a continuous flow of data from the industry for the use of policy makers. A model which has been tested, refined, and designed for policy analysis will be made available to the government. The model can be used to tell the government where and how to attain criteria variables which are necessary for decision making.

The study will also provide the government with information from fisheries sector analysis which can be combined with similar sector information from sector analyses from other agricultural sectors. The information will be useful for constructing input/output tables for the agricultural sector of the economy. These tables are useful for intersectoral analyses of the Federal Ministry of Economic Development and Construction and the Federal Office of Statistics. They are also useful for inter- and intra-ministrial interactions and for the construction of national input/output tables.

Earlier in the thesis we discussed the problem of shortage of trained personnel, especially for the planning division of the fisheries department. This project may help rectify the shortage because the teaching materials and experience gained during the course of the project can be used for training both government and private firms' staff. In addition, some members of the project, particularly the graduate research assistants would have undergone practical training on the project. The experience gained from the work will enable them to perform the duties of fisheries planning officers.

By their interactions on this project, the members of the academic community and the decision makers will establish a relationship which will be an asset to both. The university personnel will be able to draw upon the skills, concepts, normative and positive information, and knowledge of administrators and decision makers in their (university personnel's) investigations into developmental problems and into the ways and means of solving them. The investigators' problem-solving orientation will make their work relevant to the practical problems faced by the government and this will justify and induce public allocation of resources to higher education. The decision makers, on their part, will be able to draw upon the skills, concepts, and descriptive and prescriptive information of the university personnel--economists, educators, mathematicians, biologists, statisticians, sociologists, etc.--in their search for criteria variables for choosing among several alternative programs, projects, and policies.

Furthermore, the approach proposed here, i.e. GSASA, can be used in the other sectors of the economy. For example, it may prove useful for analyzing policy alternatives in nonagricultural industries such as the oil industry, or for studying consequences of education, retail trade, market and road construction, and national service policies.

Finally, the model, an output of the study, will provide the government with analyses of consequences of alternative policies, every time it is used, pinpointing the advantages and the disadvantages of different policy alternatives. However, the choice of a policy or basket of policies will be that of the decision maker or the government; the investigators can only hope that the government's or the decision maker's choice will be such that the benefits outweigh the costs. In other words, that the decision maker's choice of policy is such that the amount of "goods" attained is greater (much greater) than the amount of "bads" that are unavoidable because it is difficult to confer benefits on some people without imposing some costs on the same or other people in the same society.

This author is convinced that the fact that costs and benefits are not always reducible to monetary measures does not reduce the value of the benefits of this project and that its benefits outweigh its computable and uncomputable costs.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Summary

The objectives of this thesis were: (1) to provide a conceptual framework for policy analysis in fisheries development, which will enable a team of investigators to identify relevant variables and, hence, the kinds of data and investigations necessary for providing information that will lead to establishing or obtaining criteria for decision making; (2) to show how the framework could be used to study the Nigerian fishing industry; (3) to identify and list the kinds of data required to apply the framework to the analysis of policy problems in the canoe fishery component; (4) to develop a program for obtaining those data; and (5) to examine the costs and benefits of research in general and of the proposed project in particular.

In this thesis we have described the development of Nigeria's fisheries organization with respect to policy formulation, research and development efforts, and resource allocation. The description covered the period between 1942 (when the organization was first established as a result of World War II needs) and 1972 and the six components of the fisheries. The components include canoe, trawl (inshore and distant-water), pond, riverine, and lake fisheries. It also covered fisheries resources, production, marketing and distribution, and research activities, staff, and equipment. The need for research and development coordination at the federal level including a data bank and collection of basic data on regular basis was established.

In developing the approach presented in Chapter II we noted that neoclassical assumption of perfect knowledge is unrealistic for investigations of developmental problems. We argued, apriori, that there is neither perfect knowledge nor perfect ignorance in the real world; that what we have are degrees of knowledge which can be improved through the process of learning. Development planning was described as activities designed to achieve a future situation from an inferred present one, and inferences as subjective interpretations of our sense perceptions thus establishing the need for interaction between investigators and decision makers--the focal point of GSASA.

It was argued that GSASA follows the principles of traditional scientific research method and is particularly flexible. Using diagrams, the iterative process of GSASA for solving developmental problems was described, parallels and distinctions were shown between GSASA and the Bayesian approach, and appropriate roles for specialized techniques within the GSASA framework were discussed.

The problems of development and particularly fisheries development problems were then discussed. The main problem of fisheries development was identified as the allocation of scarce resources in an environment of complex interactions among physical, social, economic and political components, the interactions involving multiple and often conflicting values. Several needs were identified including the need to eliminate or reduce malnutrition. It was argued that acquisition of information was a necessary step to solving developmental problems and that planning is an intersectoral activity. It was argued apriori that there were legal, administrative, and political bases for implementing policy alternatives that might be found admissible for seeking solutions to developmental problems.

It was shown that GSASA can be used to study development policies in fisheries by showing conceptually how Nigeria's fisheries can be studied using GSASA. An example of a simultaneous equations system was given for the harvesting block (of Figure 4.3) and problems associated with its use discussed. Later, a case was made for the use of nonstochastic equations in analysis of data. The practicality of the approach (GSASA) was then demonstrated by constructing a preliminary operational model of a component of Nigeria's fisheries subsector. This model will be tested and refined later in Nigeria. The preliminary model computes total fish production from active labor force, gear units, and boat efforts. The amounts of fish processed and marketed were considered proportional to the amount caught or harvested. Income and prices are generated separately while resource allocation decision processes (private and public) are viewed as separate but interacting aspects of the system.

The need for data in policy analysis and the data requirements of the fisheries subsector were discussed. A preliminary list of data that need to be collected was given for nine data categories; this was followed by a discussion of procedures for collecting the data. A six-stage research plan was outlined. This was followed by a discussion of personnel needs and possible sources of research funds.

Costs and benefits were discussed first from a general perspective and then with specific reference to our proposed research project. In discussing specific costs and benefits of the project, both monetary and nonmonetary costs and benefits to ordinary Nigerians, fishermen, investigators, and the government were considered. The benefits of the project were seen to be greater than the costs of it.

General Conclusions

Even though the potential usefulness of the approach proposed here is in its promise for policy, program and project problem analysis, the exercise has helped lay a basis for understanding the Nigerian fisheries industry, policy formulation, and research activities and their coordination. It also provided a research approach for problem analysis.

From this exercise we have been able to put together an initial description of the Nigerian fisheries industry (Chapter I) which led to a useful preliminary identification of problems and needs of the industry (Chapters I and III). It was obvious from the description of Chapters I and III that the industry suffered from a lack of federal coordination of policies and research activities. Because of this lack of coordination, national policy research results are not now available for use.

The model proposed in Chapters IV and V showed the fisheries industry as a subsystem of the national economy (Figure 4.1) which implies that fisheries as a system must be viewed within a larger system even though it can be studied as a separate system (Figure 4.3).

From the construction of the preliminary model of Chapters IV and V and the subsequent research plan of Chapter VI, we can conclude that this study has been useful in identifying data needs and requirements both from the fisheries subsector and from nonfishing sectors; and also in compiling a preliminary list of relevant data that will be required for operationalizing the model.

We emphasized the need for a flexible approach for policy analysis because most of the existing specialized techniques are either inadequate for policy analysis or are usually used prematurely. Development planners are always seeking the simultaneous achievement of multiple objectives from their limited resources through different policies. There are four fundamental difficulties that may be encountered in selecting the policy and/or program which will best solve this development problem. These difficulties are: (a) the absence of a common denominator among the "goods" being sought by planners and the "bads" being avoided; (b) the absence of interpersonal validity in a common denominator when one is available; (c) the absence of the second order conditions necessary to maximize the common denominator; and (d) the absence of an appropriate decision-making rule for choosing the right policy and/or action among many alternatives open to the planner, especially when knowledge is imperfect.

Many of the specialized techniques, particularly LP, assume the existence of a single objective which can be maximized or minimized, the existence of the mathematically necessary second-order condition for the existence of a maximum, and a decision rule. Implicit in the assumption of the existence of a single objective is the existence of a common denominator which is interpersonally comparable if proposed changes damage some persons in order to benefit others. In LP objectives are also treated as given, thus eliminating the need for interaction between investigators and policy makers to determine values. Thus the specialized techniques, especially LP, constrained by single objective functions, are inadequate for solving developmental problems in the sense that they contribute little to resolutions of the first difficulty. If they are to be used to evaluate the consequences of policies and programs which impose losses on some in order to confer benefits on others, then the second difficulty must be resolved. Premature application of maximizing techniques without resolving these difficulties produces inappropriate and misleading solutions to developmental problems. Interaction among investigators and policy makers is necessary for resolving these difficulties and the flexibility of GSASA provides this interaction.

Like LP and NLP, benefit-cost analysis has specific requirements and assumptions. It also requires that the four fundamental difficulties be resolved for its meaningful applications. Since its decision rule is based on the benefit/cost ratio, it also requires a common denominator to quantify and construct a benefit/cost ratio. In Chapter VII we discussed the impossibility of quantifying all the benefits that may accrue to a nation from any development project.

Regression analysis depends entirely on cross-section and/or time-series data and classical regression assumptions of normality, independence of explanatory variables or absence of multicollinearity, homoskedasticity, etc. for its use. These assumptions are usually unsatisfied in the real world and this limits the usefulness of this approach.

Furthermore, the models and components involving the use of specialized techniques often consist of simultaneous equations requiring expansive matrix inversions. Such expanses make retooling and refining of models difficult.

The flexibility of GSASA allows, on the other hand, the use of LP and NLP within its framework when conditions for their use are satisfied thus incorporating whatever advantages there are in their use. Also, the flexibility of GSASA with respect to types and sources of data for estimating values of parameters and endogenous variables may make GSASA a cheaper approach to use than the specialized techniques because matrix inversions may not be necessary.

The flexibility of GSASA, in addition, provides a means for computing the consequences of contemplated courses of action through time, in view of what is known about the system. These consequences can be considered during interaction among policy makers and investigators with a view to further developing, extending, and refining knowledge of the various "goods" and "bads." This may resolve the first two difficulties. Secondly, the interaction approach can also be used to establish the sequence in which different action programs should be undertaken, thus resolving the order problem. Thirdly, consequences of alternative decision rules can be projected and studied and, through interaction again, a decision-making rule chosen.

GSASA is an iterative process which includes all the steps of the scientific method but superior to it because of the interaction it (GSASA) permits. It is analogous to the Bayesian approach in its first two stages but superior to it because it can handle multiple objectives and criteria, a process it handles in its stage III.

While GSASA is flexible enough to incorporate the use of simultaneous systems of equations of the Cowles Commission variety, we can conclude from the discussion of mathematical modeling and the use of nonstochastic equations (Chapter IV) that when conditions for their use are not satisfied the use of exact equations may be preferred.

The presentation of GSASA model in diagrams as in Chapter IV facilitates interaction with policy makers and interaction is the focal point of the approach.

From the problems of research discussed in Chapter I and the research plan presented in Chapter VI, it can be concluded that team research work involving both technologists and institutionalists is needed. It is through the cooperation of Nigerian investigators, decision makers, and itinerant researchers and consultants that the study proposed here can achieve its objective of providing information for selecting the best among several policy alternatives. The research experience of itinerant researchers and consultants over a wide range of subjects and countries (developed and developing) will be a tremendous asset to the type of study envisaged in this thesis.

The model, as conceptualized in Chapter IV, is not limited to the canoe component as might be inferred from Chapter V. It can be used, by slight modifications of equations in Chapter V, to study lake fisheries, pond fisheries, riverine and industrial marine fisheries (trawling and distant-water).

In the case of lake fisheries the biomass source becomes the lake and the potential yield can be more easily determined than that of the coastal waters. The control of fish growth becomes easier because of the lake's limited area. The villages are fewer in number and hence the population can be followed more easily. The same processes of harvesting, processing, and distribution which are followed in the canoe component are followed in the lake fisheries. The riverine and pond fisheries follow essentially the same patterns and can be modeled in the same way.

The industrial marine (trawling and distant-water) fisheries are different in two ways. They operate farther out on the sea and require large capital investments. Otherwise they are basically the same as the canoe component. They can also be modeled in the same way, the only exception is that while the canoe fishing unit has part of its labor requirement supplied by the family, almost all of the industrial fishing unit hires its labor. While the trawling units do not sell fresh fish, the canoe units do. All these differences can be handled by modifying the relevant equations to describe trawling instead of canoeing but the principle as presented in Chapter IV remains unchanged.

In Chapter V, processing and distribution (marketing) are not modeled separately but they can be. As our knowledge of the system improves, it may be necessary to model these processes separately in order to evaluate policies that are designed to effect changes in them.

Our model, if computerized, can easily and cheaply perform sensitivity tests to determine whether any policy has merit under changes in various elements of the system and of the basic data. An important advantage of this type of model is that the sensitivity tests may also reveal that certain data do not have to be made more accurate because the findings or results are more sensitive to other elements in the system and that conversely other data do have to be made more accurate. This implies that our proposed research can help identify relevant data needs and focus subsequent studies more sharply on the crucial data and avoid the cost of collecting irrelevant data.

The model can also be used to study fishermen's perceptions, reaction thresholds, and decision making as indicated in Chapter V. Another area of study that the model can be used in is the resource and manpower movement (migration) between the fisheries subsector and the rest of the economy through a detailed study of "market and inter-sectoral trade" of Figure 4.1.

In summary, this thesis shows that GSASA can be used to construct a fisheries model useful and valuable in Nigeria's struggle against uncertainty and lack of data in the developmental planning process. It can provide a comprehensive view of a complex and dynamic system while at the same time facilitating interactions and policy experimentation and motivate multidisciplinary research. The approach may call for a high initial cost which reflects the costs of data collection or acquisition, processing, and model building but it will have a relatively low recurrent cost as the model is used to explore a multitude of policy alternatives.

Specific Conclusions

Apart from contributing a comprehensive overview of Nigerian fisheries with respect to research activities, production process, resources, processing, and marketing; a comprehensive identification of fisheries development needs and problems; a preliminary model for studying fisheries policy problems; a research plan to study fisheries policies at both the state and national levels; a basis for establishing data bank for Nigerian fisheries; and showing that it is possible to use GSASA for fisheries policy and program analysis this thesis has led the author to the following specific conclusions.

1. From the analysis of needs (Chapter III) it can be concluded that:

   a. malnutrition is a serious problem;

   b. lack of effective demand contributes to low protein intakes;

   c. fisheries can be developed as one of the primary sources of protein especially in the southern states where lack of effective demand contributes to the low intakes of protein;

   d. providing information through data collection and policy analysis is a necessary step to seeking solutions to developmental problems; and

   e. research efforts are an admissible component of a policy designed to seek solutions to developmental problems.

2. In the preliminary stages of a research project in an LDC lacking time series data, it may be premature to use simultaneous equations system of the Cowles Commission variety for modeling an economic sector. In addition premature use of specialized techniques such as LP, benefit/cost analysis, etc., will lead to misleading

prescriptive information. However, when the rules for their use are satisfied GSASA is flexible enough to incorporate them.

3. Because of problems associated with error elements dealing with behavior and those associated with aggregation; and because

   a. exact equations permit the study of consequences of policy alternatives under strictly given set of prices and assumed known technology;

   b. a large part of economic theory was received in the form of exact equations; and

   c. exact equations can be a means of reaching reasonably realistic explanations of how the private and public decision processes interact to affect a system or its components it is concluded that exact equations are more appropriate for the preliminary stage of our study.

4. Because of new and better information which can be made available to administrators to make their administration of scarce resources generate better performance, thus giving them credit for improved performance of the system, it can be

concluded that this project provides an opportunity for administrators to perform their duties more adequately.

5. Because this project will provide

   a. a basis for data collection;

   b. a model for analyzing programs, projects, and policy alternatives;

   c. a process of on-the-job training for government personnel;

   d. teaching materials for university personnel; and

   e. information in the form of new ideas and new concepts of problems and needs, new scientific information, new technical concepts, models and theories and new skills and materials all of which have values that, though unquantifiable, can be appreciated, it can be concluded that it is not always necessary to quantify benefits before they can be perceived.

6. Because it is necessary to justify and provide a sound basis for federal allocation of funds to states, ministries and departments, it is essential to have information on the performance of previous, present, and projected programs,

projects, and policies; and because GSASA provides an approach for obtaining such information it can be concluded that this project can help administrators in their search for information necessary for making a good case for their departments.

7. From the discussion of costs and benefits (Chapter VII) it can be concluded that costs depend on price (salary) of researchers, price of research facilities, and political situation in the particular country and that by using existing information we can reduce costs without reducing benefits. It can also be concluded that costs of a research project include: (a) ordinary citizen's opportunity costs; (b) fisherman's opportunity costs of giving up his old ways of life, e.g., his traditional techniques given up to adopt new modern techniques, earnings given up for the time spent with investigators and the time spent in learning new skills, and cost of seeking new jobs; (c) investigators' opportunity costs and (d) costs to the government.

8. The specific benefits include elimination or reduction of malnutrition for the average or ordinary citizen and for (a) the fisherman benefits include: i. availability of information

on new techniques, new materials, government policies, prices, biomass sources, and on input procurement, ii. increased income and effective demand, and iii. better nutrition; (b) the investigators'benefits include: i. personal satisfaction, ii. acquisition of teaching materials, new knowledge and material for publications, iii. increased income through promotion, iv. professional recognition and v. establishment of government/university relationship; (c) the government benefits include: i. expanded data base for policy analysis, ii. establishment of permanent data collection process, iii. continuous flow of data from the industry for policy analysis and program and project evaluation, iv. acquisition of a model, tested, refined, and designed for policy analysis and which is repeatable at low cost for obtaining criteria variables for decision making, v. acquisition of information from fisheries sector analysis for use with other agricultural subsectors and for constructing fisheries portion of agricultural input/output tables which are useful for inter- and intra-ministerial interactions, vi. on-the-job training for government personnel, vii. availability of teaching material and training opportunities for the government and private sector's staff in the universities, viii. availability of highly trained potential staff from the graduate assistants for the planning divisions of state and federal ministries, ix. availability of analyses of consequences of policy alternatives and projections of criteria variables every time the model is used, and x. establishment of university/government relationship.

From the foregoing it can be stated that the benefits that will be derived from this proposed research project are much more than it will cost.

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